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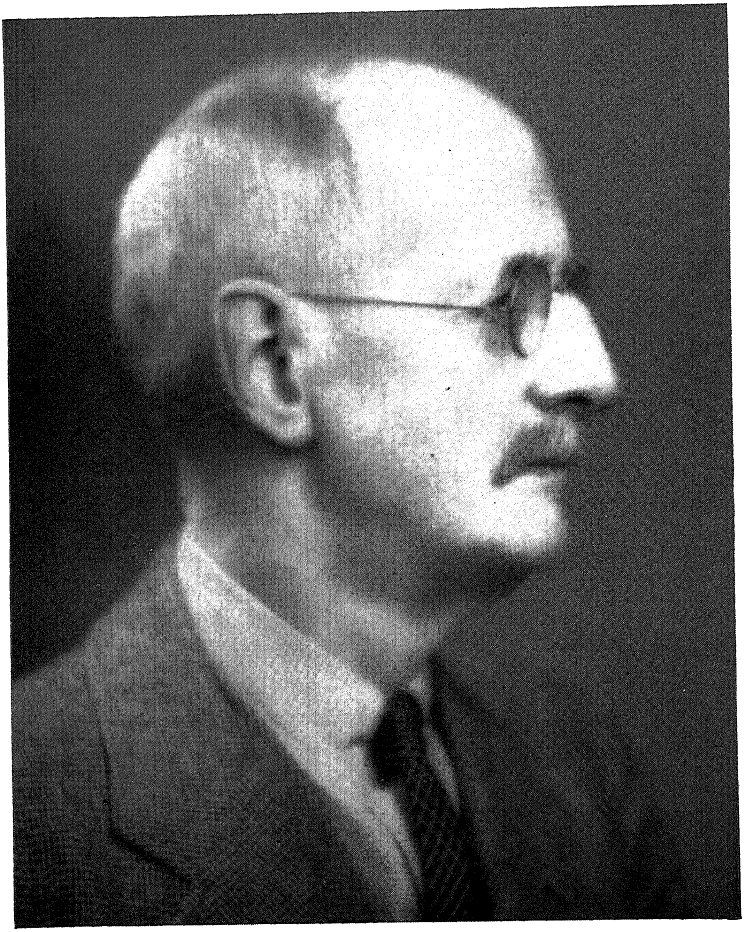


Harry Fielding Reid.

HARRY FIELDING REID

1859–1944

BY ANDREW C. LAWSON and PERRY BYERLY

Harry Fielding Reid was born May 18, 1859 in the city of Baltimore and died June 18, 1944. As a boy he went to school in Lausanne, Switzerland, where the family lived for some years. Returning to Baltimore about the time of the opening of Johns Hopkins University, he became a student in that university, receiving from it his bachelor's degree in 1880, and his doctorate in 1885. In 1886 he was appointed Professor of Mathematics at the Case School of Applied Science, Cleveland, and in 1889 became Professor of Physics in that institution. He occupied this chair for five years, after which he became attached to the geological staff of the University of Chicago as Associate Professor of Physical Geology and then returned to Johns Hopkins University, where in 1901 he became Professor of Geological Physics. The title of this department became that of Dynamic Geology and Geography in 1911 and he continued as its head until 1930, when he retired.

Besides his academic work he assumed from time to time various other scientific duties connected with public service. He was chief of the highway division of the Maryland Geological Survey from 1898 to 1905; expert in charge of earthquake records, U. S. Geological Survey, 1902-14; member of the Commission Internationale des Glaciers; representative of the United States in the International Seismological Association from 1906 on; honorary member Société Helvétique des Sciences Naturelles; corresponding member Philadelphia Academy of Natural Sciences. He was elected to the National Academy of Sciences in 1912. He was also a Fellow of the Geological Society of America; a member of the American Physical Society; the Washington Academy of Sciences; American Philosophical Society; the Seismological Society of America, of which he was President in 1913; and the American Geophysical Union (chairman, 1924-26). In 1906 he was appointed by Governor Pardee a member of the California State Earthquake Investigation

Commission. In 1911 he was Hitchcock Lecturer at the University of California. In these Hitchcock Lectures he gave an admirable exposition of the new Elastic Rebound Theory of Earthquakes. He wrote parts VI, VII and VIII of the Highways of Maryland, 1899, and was joint author with A. N. Johnson of the Second Report on the Highways of Maryland, 1902. He is also the author of Volume II of the report of the California State Earthquake Investigation Commission, 1910. In 1915, at the request of the President of the United States, he reported on the possibility of controlling the landslides at Panama. Besides these varied activities he continued throughout his life to publish papers and monographs on particular problems in the geological periodicals.

The scientific problems which concerned Reid throughout his life fall chiefly into two general categories. From 1892, when he first began to publish the results of his scientific studies, until 1907 his printed writings had to do almost wholly with the description and discussion of glaciers. He contributed much to our knowledge of the more obscure features of the glaciers of Switzerland, Alaska, Washington, and Oregon, and became the recognized leader in such investigations.

The great California earthquake in 1906 diverted him from glaciers to the study of stresses and movements in the earth's crust. From that date onward his published papers indicate clearly his devotion to seismological studies. In the list there are a few discussions of glacial questions, which appear to be hold-overs from the previous cycle.

The principal outcome of Reid's seismological work was the formulation and discussion of the theory which he named "The Elastic Rebound Theory of Earthquakes," now generally recognized as an important advance in the science of geology.

Personally, Reid was blessed with a charming character. It was always a joy to meet him; and his interests not only in science but in the ordinary affairs of life covered a wide range. To his friends he was open-hearted and cordial, although he may have appeared somewhat austere to strangers. In his earlier career he was devoted to mountain climbing, a habit acquired in his studies of glaciers. He was recognized among geologists as an exceptionally clear thinker and his scientific papers were always worthwhile contributions to the problems which he discussed in them. He was a firm believer in isostasy as a fundamental geological principle; and his brief but significant papers of 1911 and 1922 have contributed much to the general acceptance of the doctrine. Reid's most important contribution to the theory of isostasy is his paper on the Influence of Isostasy on Geological Thought, published in Bulletin 78, pp. 116-122, of the National Research Council, 1931. In this important paper he sketches the history of the development of the theory of the subject and discusses various geological questions which flow from it. The paper amplifies and further clarifies the topics presented in the earlier paper in the Bulletin of the Geological Society of America in 1922. It leaves little room for doubt as to the validity and fundamental importance of the doctrine or of its acceptance by geologists.

It was as a member of the State Earthquake Investigation Commission, which studied the California earthquake of April 18, 1906, that Reid entered deeply into seismological problems. Two great contributions to seismology came out of his studies (1) the recognition of elastic rebound as the source of earthquake waves and (2) his theory of the seismograph.

The elastic rebound theory was first stated in Volume I, Part I, of the report of the Commission (1908) and was further developed by Reid in Volume II (1910), in his discussion of the mechanics of the earthquake. In his Hitchcock Lectures at the University of California in 1911, Reid presented the theory in a clear and general form. The older idea of translation of blocks of the earth's crust as a source of earthquake waves was excluded for the 1906 shock and hence probably for all shocks. The important role played by elastic forces was emphasized and a reasonable immediate source for the great energy released in an earthquake was at last taken to be that of elastic strain. The accumulation of this strain slowly is in agreement with the slowness of most geologic regional processes. Reid's masterly exposition and the theory's own reasonableness brought it immediate acceptance. The creep of geodetic triangulation stations in California since 1906 seems to be giving additional foundation to the theory, although insufficient observations have been made to date to establish it without doubt.

Reid's presentation of the theory of the seismograph in the Commission's report was the first complete treatment in the English language. As was usual for him it was thorough. Several types of suspension were treated. There was no neglect from the start of small effects in order to obtain an equation easily handled. He considered all effects, displacements, tilts, friction; and neglected no term without detailed discussion as to its probable magnitude. He treated solid friction here and in a later paper with a care not hitherto applied to the problem. In the seismographs of that day friction was important. He also detailed experiments for determining the constants of a seismograph. His chapter on the seismograph provided a handbook for the seismologist.

In the Commission's report Reid presented copies of many seismograms of the earthquake and analyzed them. His results were presented in tabular form giving the travel times of the preliminary tremors and the surface waves. He also computed the velocities of the preliminaries as a function of depth.

It is regrettable that the Report of the State Earthquake Investigation Commission was not distributed more widely, particularly in Europe where most of the seismological work was being done at that time.

Shortly after the issuance of the report Reid wrote two papers on the geometry of faults. His paper on the starting point of earthquake vibrations was the first to point out that the instrumental epicenter as determined from P alone was the point above that at which the fault *started* to break, but that the first S recorded might well come from another portion of the fault. Two later papers discussed this matter. In 1918 he wrote a paper on the velocity of tidal waves (tsunami) pointing out the error of computing average depth of the ocean from the average velocity of the waves.

In many ways we may say Reid was the first American geophysicist. He was ahead of his time and only now are we beginning to organize university curricula in geophysics to train men who, we hope, will have his mastery of both geology and physics.

KEY TO ABBREVIATIONS USED IN BIBLIOGRAPHY

Amer. Geol. = American Geologist
Amer. Geogr. Soc. Bull. = American Geographical Society Bulletin
Amer. Geophy. Union Trans. = American Geophysical Union Transactions
Amer. Journ. Sci. = American Journal of Science
Ann. Rept. Smithsonian Inst. = Annual Report of Smithsonian Institution
Arch. des Sci. Phys. et Nat. = Archives des Sciences Physiques et Naturelles
Beitr. zur Geophys. = Beiträge zur Geophysik
Carnegie Inst. Wash. Pub. = Carnegie Institution of Washington Publications
Carnegie Inst. Wash. Year Book = Carnegie Institution of Washington Year Book
Geogr. Rev. = Geographical Review
Geol. Soc. Amer. Bull. = Geological Society of America Bulletin
Geol. Soc. Amer. Proc. = Geological Society of America Proceedings
Internat. Geol. Congr. = International Geological Congress
Internat. Seis. Assn. = International Seismological Association
Johns Hopkins Univ. Cir. = Johns Hopkins University Circular
Journ. Geol. = Journal of Geology
Journ. Phys. = Journal of Physics
Md. Geol. Sur. = Maryland Geological Survey
Mem. Nat. Acad. Sci. = Memoirs, National Academy of Sciences
Nat. Acad. Sci. Proc. = National Academy of Sciences Proceedings
Nat. Geogr. Mag. = National Geographic Magazine
Nat. Res. Council Bull. = National Research Council Bulletin
Nat. Res. Council Reprint and Circular Ser. = National Research Council Reprint and Circular Series
Pan-Amer. Geol. = Pan-American Geologist
Pop. Sci. Mo. = Popular Science Monthly
Proc. Amer. Phil. Soc. = Proceedings, American Philosophical Society
Proc. Geol. Soc. Amer. = Proceedings, Geological Society of America
Seis. Soc. Amer. Bull. = Seismological Society of America Bulletin
Ter. Mag. Atmos. Elec. = Terrestrial Magnetism and Atmospheric Electricity
U. S. Coast Sur. Rept. = United States Coast Survey Report
U. S. Geol. Sur. Ann. Rept. = United States Geological Survey Annual Report
U. S. Geol. Sur. Bull. = United States Geological Survey Bulletin
Univ. Calif. Pub. Bull. Dept. Geol. = University of California Publications, Bulletin of the Department of Geological Sciences
Zeits. für Gletscherkunde = Zeitschrift für Gletscherkunde

BIBLIOGRAPHY OF HARRY FIELDING REID[1]

1892

Report of an expedition to the Muir Glacier, Alaska. U. S. Coast Sur. Rept. 1891, p. 2, pp. 487-501 (U. S. 52nd Congress, 1st Sess., House Executive Document 43, p. 2)

Studies of Muir Glacier, Alaska. Nat. Geogr. Mag., vol. 4, pp. 19-55, map.

1893

Glacier Bay, Alaska. Amer. Journ. Sci., 3rd ser., vol. 46, pp. 305-396.

1895

The variations of glaciers. Journ. Geol., vol. 3, pp. 278-288, (Science, n. s., vol. 3, pp. 867, 1896); II, vol. 5, pp. 378-383, 1897; III, vol. 6, pp. 473-476. 1898; IV, vol. 7, pp. 217-225, 1899; V, vol. 8, pp. 154-159, 1900; VI, vol. 9, pp. 250-254, 1901; VII, vol. 10, pp. 313-317, 1902; VIII, vol. 11, pp. 285-288, 1903; IX, vol. 12, pp. 252-263, 1904; X, vol. 13, pp. 313-318, 1905; XI, vol. 14, pp. 402-419, 1906; XII, vol. 16, pp. 46-55, 1908; XIII, vol. 16, pp. 664-668, 1908; XIV, vol. 17, pp. 667-671, 1909; XV, vol. 19, pp. 83-89, 1911; XVI, vol. 19, pp. 454-461, 1911; XVII, vol. 21, pp. 422-426, 1913; XVIII, vol. 21, pp. 748-753, 1913; XIX, vol. 23, pp. 548-553, 1915; XX, vol. 24, pp. 511-514, 1916.

The variations of glaciers. Arch. des Sci. Phys. et Nat., Series 4, vol. 14, pp. 301-302, 1902; Series 4, vol. 16, pp. 92-94, 1903; Series 4, vol. 18, pp. 191-194; Series 4, vol. 20, pp. 185-187, 1905.

The variations of glaciers. Zeits. für Gletscherkunde, vol. 1, pp. 178-180, 1906; vol. 2, pp. 181-185, 1908; vol. 3, pp. 180-182, 1909; vol. 4, pp. 174-175, 1910; vol. 5, pp. 197-202, 1911; vol. 6, pp. 100-103, 1911; vol. 7, pp. 201-202, 1913; vol. 8, pp. 548-553, 1915; vol. 9, pp. 56-59, 1914.

1896

Glacier Bay and its glaciers, (Alaska). U. S. Geol. Sur., 16th Ann. Rept., p. 1, pp. 415-461, maps.

Notes on glaciers. (Abstract.) Geol. Soc. Amer. Bull., vol. 7, p. 508; Amer. Geol., vol. 17, p. 101; Science, n. s., vol. 3, pp. 53-54.

Mechanics of glaciers. Journ. Geol., vol. 4, pp. 912-928.

The flow of glaciers. Johns Hopkins Univ. Cir., vol. 15, pp. 90-91.

---

[1] Prepared by Miss Mary F. Alvey. Proc. Geol. Soc. Amer. for 1914, pp. 295-298.

1897

Mechanics of glaciers; moraines and stratification. Science, n. s., vol. 5, pp. 91-92.

Stratification of glaciers and the origin of some moraines. (Abstract.) Science, n. s., vol. 5, p. 318.

1899

Qualities of good road metals and the methods of testing them. Md. Geol. Sur., vol. 3, pp. 315-330.

Stratification of glaciers. (Abstract.) Geol. Soc. Amer. Bull., vol. 10, pp. 4-5; Amer. Geol., vol. 22, 249, 1898; Science, n. s., vol. 8, p. 463, 1898.

1900

Movement of glaciers. (Abstract.) Science, n. s., vol. 11, p. 103.

Stratification and banded structure of glaciers. (Abstract.) Science, n. s., vol. 11, pp. 103-104.

1901

De la progression des glaciers, leur stratification, et leurs veins bleues. Internat. Geol. Congr. VIII, Paris 1900, Comptes Rendus, pp. 749-755.

Observations of earthquakes. Johns Hopkins Univ. Cir., vol. 20, pp. 75-76.

1902

Notes on Mounts Hood and Adams and their glaciers. Science, n. s., vol. 15, p. 906; Geol. Soc. Amer. Bull., vol. 13, p. 536, 1903.

1903

Glaciers. Mazama, vol. 2, pp. 119-122.

1904

The relation of the blue veins of glaciers to the stratification, with a note on the variations of glaciers. Internat. Geol. Congr., IX, Vienna 1903, Comptes Rendus, pp. 703-706.

1905

The reservoir lag in glacier variations. Internat. Geol. Congr., VIII, Rept., pp. 487-491.

Records of seismographs in North America and the Hawaiian Islands. Ter. Mag. Atmos. Elec., vol. 10, pp. 81-96, 177-189.

The flow of glaciers and their stratification. Appalachia, vol. 11, pp. 1-6.

The glaciers of Mt. Hood (Oregon) and Mt. Adams (Washington). Mazama, vol. 2, pp. 195-200.

1906

Studies of the glaciers of Mount Hood and Mount Adams. Zeits. für Gletscherkunde, vol. 1, pp. 113-132.

Records of seismographs in North America and the Hawaiian Islands. Ter. Mag. Atmos. Elec., vol. 11, pp. 185-197.

1907

A proof of Kurowski's rule for determining the height of the Névé line on glaciers. Johns Hopkins Univ. Cir., n. s., no. 7, pp. 21-23 (609-611); Zeits. für Gletscherkunde, vol. 3, pp. 142-144, 1908.

On the internal and basal melting of the ice of glaciers. Johns Hopkins Univ. Cir., n. s., no. 7, pp. 24-26 (612-614); Zeits. für Gletscherkunde, vol. 3, pp. 68-70, 1908.

Rapport de la Commission Internationale des Glaciers. Internat. Geol. Congr., X, Mexico, 1906, Comptes Rendus, pp. 164-170.

1908

Report of seismological committee of the International Seismological Association (Abstract.) Science, n. s., vol. 27, p. 724.

Mechanics of the California earthquake, 1906. (Abstract.) Science, n. s., vol. 27, pp. 991-992.

1909

Mr. Manson's theory of geological climates. Science, n. s., vol. 29, pp. 27-29.

Geometry of faults. Geol. Soc. Amer. Bull., vol. 20, pp. 171-196.

Seismological notes. Proc. Amer. Phil. Soc., vol. 48, pp. 303-312; (Abstract.) Science, n. s., vol. 29, p. 833.

Observations on glaciers. Canadian Alpine Journ., vol. 2, pp. 92-96.

1910

The California earthquake of April 18, 1906. The mechanics of the earthquake. Volume II of the Report of the (California) State Earthquake Investigation Commission (Carnegie Inst. Wash., Pub. no. 87, vol. 2): 192 pp.

On mass movements in tectonic earthquakes and the depth of the focus. Beitr. zur Geophys., vol. 10, pp. 318-351.

Additional note on the geometry of faults. Geol. Soc. Amer. Bull., vol. 21, pp. 737-740.

The mechanics of faults. (Abstracts.) Science, n. s., vol. 32, p. 191; Geol. Soc. Amer. Bull., vol. 21, p. 766.

How could an explorer find the pole? Pop. Sci. Mo., vol. LXXVI, pp. 89-97.

1911

The elastic-rebound theory of earthquakes. Univ. Calif. Pub. Bull. Dept. Geol., 6, pp. 413-444.

Isostasy and mountain ranges. Proc. Amer. Phil. Soc., vol. 50, pp. 444-451; Amer. Geogr. Soc. Bull. 44, pp. 354-360, 1912; (Abstract.) Science n. s., vol. 33, p. 907.

Remarkable earthquakes in central New Mexico in 1906 and 1907. Seis. Soc. Amer. Bull. 1, pp. 10-16.

The earthquake of southeastern Maine, March 21, 1904. Seis. Soc. Amer. Bull. 1, pp. 44-47.

1912

List of strong shocks in the United States and dependencies. Report of the British Association for the Advancement of Science, vol. 81, pp. 41-45.

On the choice of a seismograph. Seis. Soc. Amer. Bull. 2, pp. 8-30.

On the nomenclature of faults. (Abstract.) Science, n. s., vol. 35, p. 319; Geol. Soc. Amer. Bull., vol. 23, p. 74.

The formation of mountain ranges. (Abstract.) Coal Age, vol. 1, p. 703.

Note on mountain-producing forces. (Abstract.) Geol. Soc. Amer. Bull., vol. 23, p. 71.

The transmission curve. Internat. Seis. Assn., Manchester 1911, Comptes Rendus, pp. 265-267.

Earth movements and earthquakes during the elevation of mountain ranges. Internat. Seis. Assn., Manchester, 1911. Comptes Rendus, pp. 273-274.

1913

Determination of the constants of a seismograph. Seis. Soc. Amer. Bull. 3, pp. 24-33.

(With others) Report of the committee (of the Geological Society of America) on the nomenclature of faults. Geol. Soc. Amer. Bull., vol. 24, pp. 163-186. (Preliminary edition with the title Proposed nomenclature of faults, subject to revision, was printed May 1, 1912.)

Sudden earth-movements in Sumatra in 1892. Seis. Soc. Amer. Bull. 3, pp. 72-79

1914

The influence of earthquake disturbances on suspended magnets. Seis. Soc. Amer. Bull. 4, pp. 204-214.

Earthquake sea waves. (Abstract with discussion.) Geol. Soc. Amer. Bull., vol. 25, pp. 33-34.

The Lisbon earthquake of November 1, 1755. Seis. Soc. Amer. Bull. 4, pp. 53-80.

1915

Constitution of the interior of the earth as indicated by seismological investigations. Proc. Amer. Phil. Soc., vol. 54, pp. 290-297. Ann. Rept. Smithsonian Inst., 1916, pp. 234-239 (1917).

1917

Note on the earthquakes at Almirante, Republic of Panama, in April, 1916. Seis. Soc. Amer. Bull. 7, pp. 27-30.

Geometric plans of the earth, with special reference to the planetesimal hypothesis. (Abstract.) Geol. Soc. Amer. Bull., vol. 28, p. 124.

1918

Note on the velocity of long waves and the average depth of the ocean. Seis. Soc. Amer. Bull. 8, pp. 34-37.

The starting point of earthquake vibrations. Seis. Soc. Amer. Bull. 8, pp. 79-82.

1919

(With Stephen Taber) Recent earthquakes of Porto Rico. (Abstract.) Geol. Soc. Amer. Bull., vol. 30, pp. 83-84.

(With Stephen Taber) The Porto Rico earthquake of 1918, with descriptions of earlier earthquakes. U. S. 66th Congress, 1st Sess., House of Representatives. Doc. no. 269, 74 pp., 8 pl.

(With Stephen Taber) The Porto Rico earthquake of October-November, 1918. Seis. Soc. Amer. Bull. 9, pp. 95-127, 8 pl.

1920

(With Stephen Taber). The Virgin Islands earthquakes of 1867-1868. Seis. Soc. Amer. Bull. 10, pp. 9-30, 3 figs.

The distribution of land and water on the earth. Proc. Amer. Phil. Soc., vol. 59, pp. 313-323, 3 figs.

The problems of seismology. Nat. Acad. Sci. Proc., vol. 6, pp. 555-561; Nat. Res. Council Reprint and Circular Ser., no. 11, pp. 555-561.

1921

Orogenic forces. (Abstract.) Geol. Soc. Amer. Bull., vol. 32, p. 33.

1922

Some astronomical tests of the planetesimal hypothesis. (Abstract.) Geol. Soc. Amer. Bull., vol. 33, p. 140.

Isostasy and earth movements. Geol. Soc. Amer. Bull., vol. 33, pp. 317-326.

1924

The movement in the slides (Panama Canal Zone). Mem. Nat. Acad. Sci., vol. 18, pp. 77-84.

The planetesimal hypothesis and the solar system. Amer. Journ. Sci., 5th ser., vol. 7, pp. 37-64.

The seismograph and friction. (Abstract.) Nat. Res. Council Bull., vol. 7, pt. 5, no. 41, pp. 97-98.

1925

The interpretation of the seismogram. Nat. Res. Council Bull. no. 53, pp. 50-51.

The influence of friction on seismographs. Seis. Soc. Amer. Bull. 15, pp. 222-241.

1926

Earthquakes and the weather. Geogr. Rev., vol. 16, pp. 152-153.

Dynamics of faulting. (Abstract.) Geol. Soc. Amer. Bull., vol. 37, p. 166; Pan-Amer. Geol., vol. 45, pp. 164-165.

1927

The fundamentals of isostasy. (Abstract.) Science, n. s., vol. 65, p. 480.

1930

Folding and faulting of strata. (Abstract.) Pan-Amer. Geol., vol. 53, pp. 76-77; Geol. Soc. Amer. Bull., vol. 41, p. 53.

1931

The influence of isostasy on geological thought. Nat. Res. Council Bull. 78, pp. 116-122.

The origin of earthquake waves. Amer. Geophy. Union Trans., 12th Annual meeting, pp. 67-70; Nat. Res. Council, June, 1931.

1933

Glaciers and geophysics. Amer. Geophy. Union Trans. 14th Annual Meeting, 1933, pp. 28-39; Nat. Res. Council, June, 1933.

The mechanics of earthquakes; the elastic rebound theory; regional strain. Nat. Res. Council Bull. no. 90, pp. 87-103.

Magnetic effects attributed to earthquakes. Nat. Res. Council Bull. no. 90, pp. 83-86.

The conception of the focus. Nat. Res. Council Bull. no. 90, pp. 104-105.

1934

(With others.) Seismology report of the advisory committee. Carnegie Inst. Wash. Year Book 33, pp. 349-359.

1935

(With others.) Seismology report of the advisory committee. Carnegie Inst. Wash. Year Book 34, pp. 93-112.

1938

Faults. (Abstracts.) Geol. Soc. Amer. Proc. 1937, p. 106.

1941

A Great American Physicist, Henry A. Roland. Journ. Phys., vol. 19, pp. 117-119.

William C. Bray

WILLIAM CROWELL BRAY

1879–1946

BY JOEL HENRY HILDEBRAND

William Crowell Bray was born September 2, 1879, at Wingham, Ontario, Canada, of good English stock. His grandfather, William Bray, born in Portsmouth in 1814, had served for eighteen years in the Royal Navy before settling in Ontario, Canada, where he engaged in business, and, late in life, became a chemist. He was described by his eminent grandson as "active in mind and body, a lover of music, and, although quiet and retiring, a natural leader in municipal, church and military affairs." One of his four sons, William Thomas Bray, the father of William C., was born in Adelaide, Ontario, in 1847. He became a pharmacist. He was characterized as "able, energetic, interested in chemistry and literature, and a social favorite." When he was but 35 years old, he contracted pneumonia following his rescue of a friend from drowning, and died, leaving a widow and two children, William Crowell, 3 years old, and Ethel Kathleen (now the wife of Professor Otto Mathey-Zorn, of Amherst College).

William Crowell's mother was a Willson, descended from a family of Cromwell supporters, who came from England in 1660. His great-great-grandfather, Crowell Willson, a "United Empire Loyalist," left the states for Canada in 1777 and settled in the Niagara peninsula. He served as a member of the parliament for Ontario. The grandfather of William Crowell Bray, who was also named Crowell Willson, served for 32 years as a member of parliament, both before and after the Confederation. He was a manufacturer and financier. After the untimely death of young William Crowell's father, mentioned in the preceding paragraph, this grandfather came to live with the widowed mother and her two little ones. He has been remembered with great respect and gratitude by them both.

Nine years later the mother died, and the 12-year-old lad went to London, Ontario, to live with a great-uncle and aunt, where he became a day pupil at the Collegiate Institute of that city. He was able to matriculate in Toronto University in 1897, but was persuaded to remain in the Collegiate Institute for a post-graduate year because he was an "immature, shy lad." In the University, the following year, he came under the influence of the distinguished and stimulating chemist, Professor W. Lash Miller. Bray proved to be an apt student; he graduated with honors in 1902 and was awarded a traveling fellowship. His first publication, in 1903, entitled "The rate of reactions in solutions containing potassium iodide, potassium chlorate, and hydrochloric acid," describing work done while still an undergraduate, is notable in that it set the course he was to follow during a lifetime of research devoted mainly to the kinetics of inorganic reactions, especially those involving compounds of the halogens.

His traveling fellowship took him to Leipzig, to the school of Wilhelm Ostwald, where physical chemistry had been receiving its main impulse. Here he came chiefly under the influence of Professor R. Luther, under whose direction he worked his thesis for the Ph.D. degree, awarded in 1905. A long paper on the hydrogen halides was published in four parts in the Zeitschrift für physikalische Chemie, in 1906, and, in the same journal and year, a study of the reactions of chlorine dioxide with the chlorine acids.

In Leipzig, he met a number of American students, including Arthur B. Lamb, who later achieved professional distinction. Although at that time he was very much a Canadian, he joined the "American Colony Club." These contacts opened the way for an invitation in 1905 to join the remarkable group of young physical chemists, including such men as Gilbert N. Lewis, Richard C. Tolman, Edward B. Washburn, and Charles A. Kraus, gathered by Arthur A. Noyes at the Massachusetts Institute of Technology. No less than eleven papers bear witness to his activity during the seven years which he spent in the laboratory at the Institute. Doubtless the most notable fruit of this period was the System of Qualitative Analysis which he worked out in partnership with A. A. Noyes and E. B. Spear, and published in four long papers in the Journal of the

American Chemical Society. In this comprehensive work, qualitative analysis was lifted, as never before, from the level of pure empiricism to a firm theoretical basis in the Mass Law and the Ionic Theory.

Mention should also be made of his work on the tri-iodide equilibrium, the effect of salts on the solubility of other salts, the hydrolysis of iodine and bromine, ionization in molten salt solutions, and a particularly notable paper on "The General Relation between the Concentration and the Conductance of Ionized Solutions in Various Solvents," with C. A. Kraus, published in 1913.

In 1912, he joined the group of enthusiastic young chemists gathered by Gilbert N. Lewis at the University of California at Berkeley. Here, in addition to continuing his research activity, he played a prominent part in developing the methods in both undergraduate and graduate instruction which have had wide influence throughout the United States. It was the conviction of Lewis, eagerly adopted by his young colleagues, that research and teaching should be regarded as allies, not enemies, that one must begin right in the freshman course in order to develop graduate students eager and able in research.

The laboratory manual for the freshman course, under the title, "A Course in General Chemistry," was first published in 1915, under the authorship of W. C. Bray and L. Rosenstein. It was revised and published in 1921 and subsequently, down to the present, under the authorship of W. C. Bray and W. M. Latimer. The pioneering nature of the efforts of these authors can only be appreciated by comparing the experiments in this book with those found in the average laboratory manual a generation ago, which too often consisted merely in verifying descriptive statements. The very different aims of Bray and Latimer were stated, in part, in these words, "This course in General Chemistry has been developed with the conviction that it is the duty of a university to train its students to meet new problems, and that it is more important to give the student a scientific training than it is to sort out for him those facts which may have a special bearing on the particular line of work that he is intending to follow.

"In the laboratory the effort is made constantly to throw the student upon his own responsibility especially in observing accurately and in drawing conclusions from his experiments. He is often called upon to predict results of untried experiments. Numerous questions and problems are introduced to draw attention to essential points which the inexperienced or the careless student might pass over. The problem of 'keeping the gifted student busy at his level of achievement' may be partly solved by allowing him to work slightly ahead of the rest of the class, for he welcomes the opportunity of overcoming the difficulties by his own efforts even though this involves more work than if he had waited for the class discussion."

Bray practiced what he preached. Like the other professors in the same department, during his stay at Berkeley he regularly took charge of a laboratory and quiz section of freshmen, and labored over them with a zeal which some probably did not fully appreciate till long afterwards. He was strict in his standards of industry and accuracy and he spent no time joking with students, or discussing their personal affairs, but serious students came eventually to appreciate what he had done for their minds, as illustrated by one of them out of many who later achieved distinction, Professor Don M. Yost, who dedicated his "Systematic Inorganic Chemistry" "To William C. Bray, Able Scientist, Inspiring Teacher."

Bray's first publication out of the Berkeley laboratory was a paper with G. E. K. Branch on "Valence and Tautomerism," concerning which G. N. Lewis wrote, "Out of the haze of valence theory two separate ideas stand forth prominently. Bray and Branch have performed an important service to theoretical chemistry in differentiating these two ideas and in suggesting a terminology which adequately expresses the distinction."

On the outbreak of World War I, Bray and several associates began to work upon the pressing problem of devising a gas mask to absorb carbon monoxide, which was claiming many victims of incomplete combustion in battleship turrets and in machine-gun pits. The joint efforts of Bray, Lamb, Frazer, Almquist and others, in connection with the Defense Research

Section, Chemical Warfare Service, led to the preparation of "hopcalite," (Hopkins-California) an effective mixed-oxide catalyst for the low temperature oxidation of carbon monoxide.

Bray was naturalized in 1913. He was promoted to associate professor in 1916 and to full professor in 1918. In 1919, he served as Associate Director of the Fixed Nitrogen Research Laboratory.

From his return to the University in 1920 till his death, in 1946, he and his coworkers published no less than forty-five papers. One deserving special mention was a second piece of comprehensive work on chemical analysis with A. A. Noyes, "The Systematic Detection of the Rarer Chemical Elements," in 1924. This was published in 1927 in book form. Other contributions included studies in the catalytic decomposition of hydrogen peroxide by halide-halogen couples, the oxidation of hydrazine, a rare fourth-order reaction, ferryl ion, the hydrolysis of ferric ion and the standard potential of the ferrous-ferric electrode, the interaction of ozone and hydrogen peroxide, and a general discussion of mechanisms in which he stressed the important, but often neglected, distinction between "steady states" and true equilibria.

Bray was a singularly modest, unself-seeking man. He made little effort to attract graduate students to do research under his direction, but rather emphasized to them the difficulties and discouragements involved. Some of his colleagues had to offset this by pointing out to students the rare privilege open to them of working under one of the great masters of inorganic chemistry. A limited number were intelligent enough to take advantage of the opportunity, and as a result, the average quality of the men who worked with him has been very high. Among them may be mentioned Professors J. A. Almquist, R. E. Connick, H. A. Young of the University of California; Professor J. B. Ramsey of the University of California at Los Angeles; Dr. H. A. Liebhafsky of the General Electric Company; Professor R. D. Livingston of the University of Minnesota; Dr. B. Makower of the United States Department of Agriculture Western Regional Laboratory; and Professor H. Taube of the University of Chicago.

He married Nora Thomas in 1914. They have a daughter, Margaret.

He was elected to the National Academy of Sciences, the American Academy of Arts and Sciences, and was a member of the American Chemical Society, the American Electrochemical Society, and the American Association for the Advancement of Science.

Bray took sabbatical leave from May to December, 1934, spending his time with Mrs. Bray and Margaret in European travel, and in residence for a period in Vienna, where he found congenial relations with another eminent chemist interested in kinetics, Professor Emil Abel, of the Technische Hochschule.

During the difficult war years from March 1943 till March 1, 1945, when he resigned for reasons of health, he served as Chairman of the Department of Chemistry.

He suffered a heart attack late in 1945 and was immobilized for several months. He gradually improved, and visited his office and lunched, as was his wont, at the Faculty Club, but on February 24, 1946, he was suddenly and fatally stricken. The loss of Lewis, Bray and Eastman, all within a short time, was a sore blow to the Department of Chemistry.

Professor Bray had a calm, dignified personality, but he was none-the-less good company in his quiet way. Although he took serious matters very seriously, he had a fine sense of humor. One evening, for example, at a small dinner of intimate friends at his home, he remarked almost out of a clear sky, "You know, Joel Hildebrand is the most cordially hated member of the faculty." I rejoined, "Look here, Will, isn't that putting it on pretty thick. Do I have no rival in all the faculty?" "No," he replied, "when Joel and Mrs. Joel go camping in summer in the High Sierra, Joel does all the cooking and the other faculty wives have found it out."

He belonged to a congenial group of faculty members and laymen who, in the summers of 1925 and 1926, built a lodge at 7000 feet at Donner Summit in the Sierra Nevada. The group called itself "the Sierra Ski Club," but the members took good fellowship and good conversation far more seriously than good skiing, and their chief activities were intellectual and gastronomic, around the great fireplace, rather than muscular, upon the snow. Bray was a welcome member of this group, one who always remained quite sober without being solemn.

His keen powers of observation and analysis were not exhausted in the laboratory but were further exercised as a spectator to a football game or as a "kibitzer" at a card game. Gilbert Lewis once remarked that "even if you made a 'grand slam' Bray would tell you how you could have made one more trick." And he looked upon a football game with the cold but all-seeing eye of a pure connoisseur, oblivious to the hysteria of the crowd. I once repeated to the great football coach, "Andy" Smith, an observation Bray had made to me regarding tactics in a certain game. Andy listened attentively and then said, "That man must know a lot about football."

The services of Professor Bray transcended the Department of Chemistry and reached throughout the University. He served on numerous important faculty committees as chairman and as member. The same qualities which made his work so effective in chemistry made his service effective to the University. His colleagues respected him for his wisdom and loved him for his human qualities. As stated by one of his friends in the department, "his character and university service, like his scientific achievements, have appeared the finer the more intimately they have come to be known."

KEY TO ABBREVIATIONS USED IN BIBLIOGRAPHY

Chem. Rev. = Chemical Reviews
J. Am. Chem. Soc. = Journal of the American Chemical Society
J. Indus. Eng. Chem. = Journal of Industrial and Engineering Chemistry
J. Phys. Chem. = Journal of Physical Chemistry
Proc. Nat. Acad. Sci. = Proceedings of the National Academy of Sciences
Trans. Am. Electrochem. Soc. = Transactions of the American Electrochemical Society
Z. anorg. Chem. = Zeitschrift für anorganische Chemie
Z. physik. Chem. = Zeitschrift für physikalische Chemie

BIBLIOGRAPHY

1903

The Rate of Reactions in Solutions Containing Potassium Iodide, Potassium Chlorate and Hydrochloric Acid. J. Phys. Chem., *7*, 92.

1905

On the Use of the Differential Equation in Calculating the Results of Kinetic Measurements; The Reaction between Arsenic Acid and Potassium Iodide near the Equilibrium. J. Phys. Chem., 9, 573.

1906

Beiträge zur Kenntniss der Halogensauerstoffverbindungen. Parts I-IV. Z. physik. Chem., *54*, 463-97, 569-608, 731-49.

Einige Reaktionen des Chlordioxyde und der chlorige Saüre. Z. anorg. Chem., *48*, 217.

1907

A System of Qualitative Analysis for the Common Elements. Parts I and II (with A. A. Noyes). J. Am. Chem. Soc., *29*, 137.

1908

The Same. Part III (with A. A. Noyes and E. B. Spear). J. Am. Chem. Soc., *30*, 481.

1909

The Same. Part IV. J. Am. Chem. Soc., *31*, 611.

The Ionization Relations of Ortho- and Pyrophosphoric Acids and their Sodium Salts (with G. A. Abbott). J. Am. Chem. Soc., *31*, 729.

1910

The Conductance and Ionization of Potassium Tri-iodide and the Equilibrium between Iodine and Polyiodides in Aqueous Solution (with G. M. J. MacKay). J. Am. Chem. Soc., *32*, 914.

The Hydrolysis of Iodine and of Bromine. J. Am. Chem. Soc., *32*, 932.

A Volumetric Method of Determining Iodide in the Presence of Chloride, Bromide or Free Iodine (with G. M. J. MacKay). J. Am. Chem. Soc., *32*, 1193.

A Source of Error in Permanganate Titrations: Preliminary Note. J. Am. Chem. Soc., *32*, 1204.

The Equilibrium between Solid Cuprous Iodide and Aqueous Solutions containing Cupric Salt and Iodine (with G. M. J. MacKay). J. Am. Chem. Soc., *32*, 1207.

1911

The Conductance of Aqueous Solutions of Sodium Chloride, Hydrochloric Acid and their Mixtures (with F. L. Hunt). J. Am. Chem. Soc., *33*, 781.

The Effect of Salts on the Solubility of Other Salts. I. (A) Introduction. (B) Preliminary Note on the Effect of Salts on the Solubility of Uni-bivalent Salts (with A. A. Noyes). J. Am. Chem. Soc., *33*, 1643.

The Same. III. Solubility of Thallous Chloride in Solutions of Potassium Nitrate, Potassium Sulfate and Thallous Sulfate at 25° (with W. J. Winninghoff). J. Am. Chem. Soc., *33*, 1663.

The Same. IV. Quantitative Discussion of the Solubility of Uni-univalent Salts in the Presence of Other Salts. J. Am Chem. Soc., *33*, 1674.

1912

Geschmolzene Salze als Lösungsmittel. Die Ionization darin gelöster Salze. Z. physik. Chem., *80*, 251-3, 378-80.

A General Law of Ionization for Solutions of Binary Electrolytes. Trans. Am. Electrochem. Soc., *21*, 143-54.

1913

The General Relation between the Concentration and the Conductance of Ionized Solutions in Various Solvents (with C. A. Kraus). J. Am. Chem. Soc., *35*, 1315.

Valence and Tautomerism (with G. E. K. Branch). J. Am. Chem. Soc., *35*, 1440.

1916

A Laboratory Manual of General Chemistry, Lederer, Street and Zeus Publishers, Berkeley, Cal.

1917

Experiments with Nitrogen Trichloride (with C. T. Dowell). J. Am. Chem. Soc., *39*, 896.

The Reactions between Chlorine and Ammonia (with C. T. Dowell). J. Am. Chem. Soc., *39*, 905.

1919

The Volumetric Determination of Hydroxylamine (with M. E. Simpson and A. A. MacKenzie). J. Am. Chem. Soc., *41*, 1363.

1920

The Removal of Carbon Monoxide from Air (with A. B. Lamb and J. C. W. Frazer). J. Indus. Eng. Chem., *12*, 213.

The Preparation of Iodic Acid and its Anhydride (with A. B. Lamb and W. J. Geldard). J. Am. Chem. Soc., *42*, 1636.

1921

A Periodic Reaction in Homogeneous Solution and its Relation to Catalysis. J. Am. Chem. Soc., *43*, 1262.

1923

The Catalytic Decomposition of Hydrogen Peroxide in a Bromine-Bromide Solution and a Study of the Steady State. J. Am. Chem. Soc., *45*, 1251.

A Course in General Chemistry (with W. M. Latimer). The Macmillan Company, New York.

The Catalytic Decomposition of Hydrogen Peroxide in a Bromine-Bromide Solution. II. Rate Measurements in Dilute Solutions and in the absence of Sulfate, and their interpretation as a Function of the Activity Product of Hydrobromic Acid (with R. S. Livingston). J. Am. Chem. Soc., *45*, 2048.

The Catalytic Oxidation of Carbon Monoxide. I. Efficiency of the Catalysts Manganese Dioxide, Cupric Oxide and Mixtures of these Oxides (with J. A. Almquist). J. Am. Chem. Soc., *45*, 2305.

1924

The Oxidation of Hydrazine. I. The Volumetric Analysis of Hydrazine by the Iodic Acid, Iodine, Bromine, and Hypochlorous Acid Methods (with E. J. Cuy). J. Am. Chem. Soc., *46*, 858.

The Oxidation of Hydrazine. II. The Effect of Oxygen on the Decomposition of Hydrazine. The Reactions with Ferricyanide in Alkaline Solution and Dichromate in Acid Solution (with E. J. Cuy). J. Am. Chem. Soc., *46*, 1786.

The Oxidation of Hydrazine. III. The Limiting Reaction of Permanganate and Manganic Salts in Acid Solution with Hydrazine (with E. J. Cuy and M. E. Rosenberg). J. Am. Chem. Soc., *46*, 1796.

The Standardization of Thiosulfate Solution by the Permanganate-Iodide and Dichromate-Iodide Methods (with Harry East Miller). J. Am. Chem. Soc., *46*, 2204.

The Systematic Detection of the Rarer Chemical Elements (with Arthur A. Noyes). Chem. Rev., *1*, 277-291.

1925

The Catalytic Decomposition of Hydrogen Peroxide in an Acid Chlorine-Chloride Solution (with R. S. Livingston). J. Am. Chem. Soc., *47,* 2069. *A Correction, ibid., 48.* (1926).

1926

Capillary Condensation and Adsorption (with H. D. Draper). Proc. Nat. Acad. Sci., *12,* 295.

The Catalytic Oxidation of Carbon Monoxide. II. The Adsorption of Carbon Dioxide, Carbon Monoxide and Oxygen by the Catalysts, Manganese Dioxide, Cupric Oxide, and Mixtures of these Oxides (with W. M. Hoskins). J. Am. Chem. Soc., *48,* 1454.

The Catalytic Oxidation of Carbon Monoxide. III. Catalytic Efficiency of Mixtures of Dry Manganese Dioxide and Cupric Oxide (with G. J. Doss). J. Am. Chem. Soc., *48,* 2060.

1927

"Qualitative Analysis for the Rare Elements" (with A. A. Noyes). The Macmillan Company, New York.

1928

The Rate of Oxidation of Hydrogen Peroxide by Bromine and its Relation to the Catalytic Decomposition of Hydrogen Peroxide in a Bromine-Bromide Solution (with R. S. Livingston). J. Am. Chem. Soc., *50,* 1654.

1930

The Autocatalytic Reduction of Bromate by Hydrogen Peroxide in Acid Solution (with Paul R. Davis). J. Am. Chem. Soc., *52,* 1427.

An Oxide of Iodine, I_2O_2. An Intermediate Compound. J. Am. Chem. Soc., *52,* 3580.

1931

Reactions Involving Hydrogen Peroxide, Iodine and Iodate Ion. I. Introduction (with H. A. Liebhafsky). J. Am. Chem. Soc., *53,* 38.

II. The Preparation of Iodic Acid. Preliminary Rate Measurements (with A. L. Caulkins). J. Am. Chem. Soc., *53,* 44.

1932

The Mechanism of Reactions in Aqueous Solution. Examples Involving Equilibria and Steady States. Chem. Rev. *10,* 161.

Ferryl Ion, a Compound of Tetravalent Iron (with M. Gorin). J. Am. Chem. Soc., *54,* 2124.

The Rate of the Fourth Order Reaction Between Bromic and Hydrobromic Acids. The Kinetic Salt Effect (with H. A. Young). J. Am. Chem. Soc., *54,* 4284.

A Course in General Chemistry (with W. M. Latimer). Revised Edition (159 pages). MacMillan and Company, N. Y.

1933

The Simultaneous Reduction of Vanadic Acid and Oxygen by Iodide. Induced Catalysis of Oxygen Reactions (with J. B. Ramsey). J. Am. Chem. Soc., *55,* 2279.

The Rate of Oxidation of Hydrogen Peroxide by Chlorine in the Presence of Hydrochloric Acid (with B. Makower). J. Am. Chem. Soc., *55*, *4765*.

1934

The Hydrolysis of Ferric Ion. The Standard Potential of the Ferric-Ferrous Electrode at 25°. The Equilibrium $Fe^{+++} + Cl^{-} = FeCl^{++}$ (with A. V. Hershey). J. Am. Chem. Soc., *56,* 1889.

1935

The Kinetic Salt Effect in the Fourth Order Reaction $BrO_3^{-} + Br^{-} + 2H^{+} \longrightarrow$. Ionization Quotients for HSO^{4-} at 25° (with H. A. Liebhafsky). J. Am. Chem. Soc., *57,* 51.

1936

Kinetic and Equilibrium Measurements of the Reaction $2Fe^{+++} + 2I^{-} = 2Fe^{++} + I_2$ (with A. V. Hershey). J. Am. Chem. Soc., *58,* 1760.

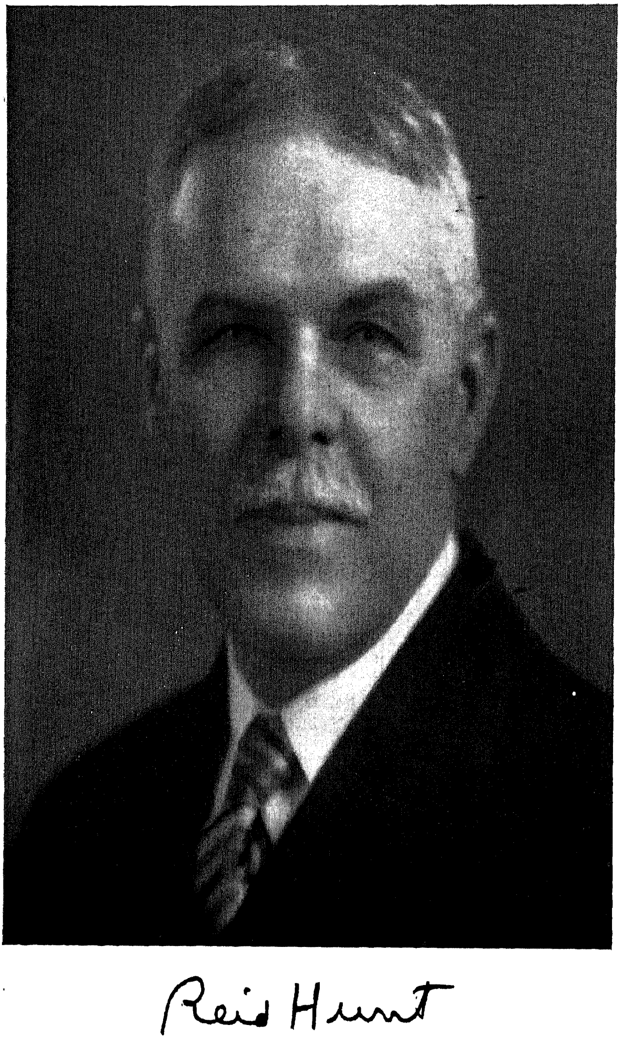
1938

The Interaction of Ozone and Hydrogen Peroxide in Aqueous Solution. J. Am. Chem. Soc., *60,* 82.

1940

A Course in General Chemistry (with W. M. Latimer). Third edition (206 pages). MacMillan and Company, New York.

Chain Reactions in Aqueous Solutions Containing Ozone, Hydrogen Peroxide and Acid (with H. Taube). J. Am. Chem. Soc., *62,* 3357.



Reid Hunt

REID HUNT

1870–1948

BY E. K. MARSHALL, JR.

"When I drive up to the Medical School through the Fenway on winter mornings, I often pass Reid Hunt striding along in all kinds of weather, his head bent forward in a thoughtful attitude and his little satchel crammed with books swinging in his hand. I think with regret, at such times, of the unfortunate circumstances which, in modern teaching of large classes with rigid curricula, prevent that close personal association between teacher and student which, in many cases, might represent the best that an educational institution could offer.

"I think also, as I watch him, of Reid Hunt the young man, starting one moonlight night many years ago to march with this same erect stride across the desert of the Sudan behind an escort of military convicts to carry his sick friend Saunders (sic) to care and safety. I see him then with eyes through which I wish his students could see him when he stands before them in the pit of the lecture hall. They would think of him, then, not only as the eminent scholar, shy beyond all display of learning, but also as the human being to whom his science has been a great adventure for the exercise of that courage and devotion which carried him and his friend safely through Kitchener's Sudan in 1898 (sic)."

These paragraphs, from Zinsser's introductory chapter of the Year Book of the Harvard Medical School Class of 1937, suggest certain characteristics of Reid Hunt: his kindness, shyness and modesty, his scholarly attitude, his encyclopedic knowledge, and his capacity for interesting, intimate conversation. For the sake of accuracy, it should be noted that Hunt took his sick friend Sumner from Berber to the railroad station, one mile away; and that instead of marching, he rode a white Egyptian donkey.

Reid Hunt was born on April 20, 1870, in Martinsville, Ohio. He was the son of Milton L. and Sarah E. (Wright) Hunt. His father was a small-town banker, and both parents were interested in literature. There was one other child, an elder brother. Circumstances were such that no work or chores were required of young Hunt at home. His interest in science and medicine was acquired early while studying chemistry with the village druggist. After graduation from the Martinsville High School at the age of 16, he attended Wilmington College and the University of Ohio (Athens) for a year each. He then came to Baltimore, entered Johns Hopkins University, and received his A.B. in 1891.

After receiving his baccalaureate degree, Hunt entered as a graduate student at Hopkins in pathology under Welch and in biology under Newell Martin for the first half of the academic year, 1891-92, but in February he sailed for Europe. Here, he registered as a medical student at the University of Bonn, and was much impressed with Binz, the Professor of Pharmacology. The next fall, we find the young scientist returned as a graduate student at Hopkins in physiology. He evidently started his work under Newell Martin and a year later continued it with his life long friend William H. Howell. He acted as Assistant in Histology and Physiology in 1892-93, and in Physiology in 1893-94. In June, 1894, he was appointed Fellow in Physiology and was reappointed in June, 1895. In 1896, Hunt received his Ph.D. in Physiology. While studying for the doctorate in physiology, Hunt, apparently unknown to the Hopkins authorities, had been attending classes at the College of Physicians and Surgeons in Baltimore. He received his M.D. degree from that institution simultaneously with his Ph.D. from Hopkins. In those days, it was quite possible to obtain both the Ph.D. and the M.D. degrees in five years. That was before the days of the Flexner report and the medical course was mostly lectures repeated from year to year. Hunt was excellently prepared, probably much better prepared than most medical students of his period.

Two years were now spent as Tutor in Physiology under Curtis at the College of Physicians and Surgeons of Columbia University. In the fall of 1898, Hunt came back to Johns Hopkins as Associate in Pharmacology. The summers of 1898 and 1899 were devoted to two expeditions to Egypt in an attempt to obtain specimens of the African lungfish and its developmental stages. Both expeditions were led by N. R. Harrington, a graduate student at Columbia. The first was sent out by the Zoology Department of Columbia University and consisted of Harrington and Hunt. Military conditions prevented the ascent of the Nile. The second expedition was financed mainly by Charles H. Senff, a friend of Henry Fairfield Osborn, and consisted of Harrington, Hunt and F. B. Sumner. This expedition went into the Sudan as far as Atbara. Harrington died of fever, and both Hunt and Sumner were stricken. Although the second expedition collected a number of local species of fish and some preserved material for histological study, neither expedition succeeded in its main objective of obtaining the lungfish.

From the fall of 1898 until the fall of 1904, Hunt was in Baltimore at Johns Hopkins with John J. Abel. In 1901, he was made Associate Professor of Pharmacology. During this period in Baltimore, two trips were made to Paul Ehrlich's laboratory at Frankfort, the first in the summer and fall of 1902, and the second in 1903. Apparently, Hunt returned to Baltimore each year to carry out his teaching duties. In 1904, he was called to the Hygienic Laboratory, U. S. Public Health and Marine Hospital Service, as Chief of the Division of Pharmacology. In 1910, his title was changed to Professor of Pharmacology. In 1913, Hunt accepted a call to become Professor of Pharmacology at the Harvard Medical School, from which position he retired as Professor Emeritus in 1936. Reid Hunt died after a long illness on March 10, 1948.

In December 1908, Reid Hunt married Mary Lillie Taylor of Washington, D. C., who survives him. They had no children.

As far as one can judge, Ehrlich exerted the most influence upon Hunt's career. His two major fields of work—the physiology and pharmacology of the thyroid gland and the relation of chemical constitution of onium compounds to their pharmacological action—stem from investigations undertaken at Frankfort. Hunt never tired of talking of Ehrlich and his Frankfort laboratory. One gets the impression that the months with Ehrlich were among the happiest of his life. Hunt believed very strongly in Ehrlich's chemotherapy, and in a letter to the Journal of the American Medical Association in 1907 (before Ehrlich's Salvarsan) he stated clearly his belief that the future therapy of infections lay in chemotherapy and not in vaccines and sera. It may be of interest to note that only a short time before Ehrlich and Shiga made their epoch making observations on the curative effect of trypan red in trypanosomiasis in mice, Hunt had started with Ehrlich the study of the action of dyes in this experimental infection. One who worked with Hunt at Harvard on the effect of organic arsenic compounds on tumor-bearing mice writes, "We never did turn the corner but in the light of all that has transpired in the field of chemotherapy in recent years, I shall always feel that it was a rare privilege to have had a chance to come in contact with one of the pioneers in the field. He certainly had a real 'vision of things hoped for' and an enthusiastic conviction that certainly received ample substantiation a few years later in the tremendous strides which have been made in chemotherapy." One wonders why Hunt, with his great belief in the future of chemotherapy, with his knowledge of the literature and with his experiences in Ehrlich's laboratory, did not work actively in this field.

In the connotation generally attached to these terms, Hunt was neither a brilliant nor a successful teacher. His lectures were delivered in a quiet, unassuming manner, and no attempt was made to cover systematically the factual content of pharmacology. These lectures proved disconcerting to most medical students, especially since at the time, there was no satisfactory text in which the subject could be reviewed. However, to the more advanced students, his lectures were intensely interesting. There were many entertaining side lights and excursions into historical aspects of his subject. Frequently, the whole hour was spent on discussion of a single point, sometimes of controversial nature. In informal conversation, Hunt was at his best and could talk in a most entertaining and interesting vein of his many and varied experiences in European and other laboratories. Hunt did not enjoy teaching and probably realized that it was not his forte. A colleague of the old days at Hopkins writes that Hunt was well pleased when he got the job in Washington with no teaching but that when the

Harvard offer came he was not quite certain he should accept it as it meant more teaching than he wanted.

Many who were associated with Hunt have told me that those who worked in his department had a high regard for their "Chief", and that an exceptional spirit of loyalty prevailed in his laboratory. This in spite of the fact that he offered no direction to students or staff members, leaving them entirely free to work out their own problems. Hunt was an individual worker and neither enlisted the assistance of his departmental staff nor discussed his own experiments with them. His experiments were performed with the help of a very capable "diener" whom he brought from Washington to Boston. In the Harvard period, only a small fraction of his time was given to actual experimentation. He unquestionably exerted a type of leadership in his department, although the reasons for this seem intangible. They probably relate to Hunt's personal charm, his intense interest in and application to his own research, and also to the fact that he was always ready with helpful advice when problems were brought to him. His quiet observations were given out of a surprisingly complete knowledge of the literature. His attractively hesitant way of putting forward his ideas made an exchange of views with him a pleasant and profitable experience. Hunt devoted many hours in the library to the reading of current literature, not only in his own field but also in the broad field of medicine. I am told that after a meeting of the Advisory Board of the Hygienic Laboratory in Washington, he would go to the library to read scientific journals before returning to Boston. One gains the impression that Hunt until the end of his scientific career was as much or more interested in acquiring knowledge as in advancing it. One of his colleagues at Harvard said to a student seeking information, "Let's go and see Hunt—The Encyclopedia". At one time on the campus at Harvard, it was said that "Hunt knew as much about chemistry as Folin, as much physiology as Cannon, and as much pharmacology as Reid Hunt." One regrets that on account of his shyness he did not in any great measure transmit his profound knowledge to those around him.

As far as I can find, Hunt had few interests outside his laboratory and his home. He was very fond of travel and delighted in visiting and talking with people in laboratories in all parts of the world. He went as a delegate to many meetings in various parts of Europe. In 1923, he was Visiting Professor to the Medical School at Peking, China. An American pharmacologist who was stationed at Peking at this time writes: "He was cautious in his decisions, whether they had to do with choice of words or with policies, plans or interpretations of research work. He was better acquainted with the literature than anyone else I have ever met. While he was there we received a sample of a Burmese arrow poison, with a request for information about it, and he at once suggested that it might be Antiarin, of which I had never heard before or since. This was easily checked and was found to be correct. He had an amazing store of general and specific information which was usually very accurate though his extreme diffidence made it difficult for him to share this." In spite of his shyness and desire to keep out of the limelight, he enjoyed an acquaintance with the leaders of medical research in this and other countries, equalled by few of his contemporaries. He was known the world over, never as Hunt, but always as Reid Hunt, despite the fact that there was no one with that surname with whom he might be confused.

Hunt's first published paper was entitled "The Fall of Blood Pressure Resulting from Stimulation of Afferent Nerves". This was published in 1895, and was submitted to the Board of University Studies of Johns Hopkins University as a thesis for the degree of Doctor of Philosophy. In this paper one finds the scrupulous attention to detail and the wide knowledge of the literature which were so characteristic of the man in later life. This research was apparently undertaken at the suggestion of Howell.

However, this was not the first research undertaken by Hunt and brought to the stage of publication. His well known work on the relation of the inhibitory to the accelerator nerves of the heart was begun before Howell returned to Baltimore, and was probably undertaken on his own initiative. Howell stated in 1934: "My acquaintance with Hunt dates back to 1893. When

I returned to Hopkins to take the chair of physiology in the newly founded Medical School, I found him in the laboratory busy with his experiments, so well known in physiology, on the results of simultaneous stimulation of the vagus and accelerator nerves of the heart."

He was later led to study the cardiac nerves of lobster, opossum, and calf, as well as the usual laboratory animals (rabbit, cat, and dog). The important result of this work was to show the antagonism of the cardiac nerves; when vagus and accelerator are stimulated simultaneously the effect is determined by relative strength of stimuli and the effect is approximately additive. This early work on the vagus and sympathetic may have led to his later interest in the pharmacology of the autonomic nervous system.

Hunt's first pharmacological work was done as a special expert of the U. S. Department of Agriculture for the investigation of poisonous plants. He succeeded in finding that the poisoning ascribed to Death Camus (Zygadenus venenosus) was due to alkaloids with pharmacological properties similar to the veratrum alkaloids. A paper in 1902, on the toxicity of methyl alcohol made the danger of this substance known to the American physician shortly after it had been recognized in Germany. During the prohibition era, he examined one hundred consecutive samples of confiscated "bootleg liquor" and was able to show that "poison liquor" owed its poisoning property mainly to the ethyl alcohol content and not to methyl alcohol or other impurities.

Most of Hunt's later work stems from two investigations which he carried out in Ehrlich's laboratory at Frankfort. The first of these was a study of the toxicity of a number of nitriles and the antidotal action of certain sulphur compounds toward them. These nitriles are toxic due to the liberation of hydrocyanic acid. There was a variation in the toxicity of different nitriles depending on the rate at which hydrocyanic acid was liberated. Some of these nitriles on a molecular basis were more toxic than hydrocyanic acid. Hunt explained this fact on the theory that the distribution of the drugs was different from hydrocyanic acid—they penetrated the nervous system before splitting off hydrocyanic acid.

The second research undertaken in the Frankfort laboratory was concerned with the toxicity of certain quinine derivatives. The problem was to determine if the vinyl group in quinine is essential for toxicity. Hunt showed that this group was without especial significance for toxicity. Of especial interest was the finding that saturation of the vinyl group with hydrochloric acid results in a compound with decreased toxicity for mammals and increased toxicity for infusoria. This suggested that derivatives of quinine may be found to be of value in protozoan diseases in which quinine is of little value.

Hunt's work on the relation of chemical constitution to pharmacological action of the choline derivatives was initiated with an observation made in 1899, although the later trend of these investigations was markedly influenced by his experience with Ehrlich. He found that extracts of the suprarenal glands, from which epinephrine had been removed, caused a fall of blood pressure in anesthetized animals, but a rise of blood pressure after the administration of atropine. He isolated choline, but found that it did not account for the full effect of the gland extract. He obtained evidence that a second body was present in the suprarenal extract which differed from choline in causing a fall of blood pressure after atropine. With chemical manipulation, the second body disappeared; at the same time, the amount of choline seemed to be increased. Later, Hunt pointed out that if choline played a part as an active physiological agent in body processes it was probably in the form of one of its more active derivatives.

These observations made at the turn of the century led Hunt, when he returned from his stay with Ehrlich and when he had moved to Washington, to study intensively derivatives and analogues of choline with the idea of relating chemical constitution to pharmacological action. His first publication with Taveau in 1906 described among other things the important discovery of the remarkable activity of acetylcholine in causing a fall of blood pressure. This preliminary paper in 1906 was followed in 1909 and 1911 by two long papers with Taveau. In the first of these, the purpose behind the investigation of the effect of drugs on the autonomic system is given. After stressing the extraordinary physiological activity and relatively slight toxicity of acetylcholine as a basis for some of these compounds having therapeutic value, Hunt writes: "Before taking up the subject, however, it seemed desirable to determine the general laws governing the toxicity of such compounds, for when these are determined it may be possible to make compounds which, while preserving the desired physiological action, have a low degree of toxicity".

The second paper concerns the effect of a large number of choline derivatives and analogues on blood pressure.

A long series of papers now appeared extending to the end of Hunt's scientific career on the action of onium compounds on the autonomic nervous system. These were mainly with the chemist, Renshaw, who had worked in Hunt's laboratory for a few years after World War I and who was later Professor of Chemistry at New York University. All types of choline derivatives and analogues were prepared and studied—the arsenic, antimony, phosphorus, and sulfur analogues of the nitrogen compounds; ethers, thioethers, etc.

In regard to this work, Hunt wroted in 1915, "Choline which has a simple structure, is readily prepared synthetically; many modifications of it, and analogous compounds, can readily be made: these vary greatly in not only the degree but in the kind of their physiological action. In fact, few fields seem more inviting for a study of the relation between chemical constitution and physiological action with the possibility of discovering drugs having certain desirable properties (upon the pupils, intestines, heart, etc.)".

The fact that acetylation of choline increased its activity in lowering blood pressure "100,000 times" impressed Hunt greatly, and he was fond of calculating the number of cats whose blood pressure could be reduced by a single milligram of acetylcholine. That he had made a discovery of the greatest biological importance, he could scarcely have realized at the time.

His studies on the action of several hundred derivatives and analogues of choline at first in regard to toxicity and effect on blood pressure and later in regard to "muscarine" action, stimulating "nicotine" action and paralyzing "nicotine" action allowed him to develop a concept of the relation between chemical structure and physiological action of these compounds on the autonomic nervous system. This enabled him to predict the properties of certain compounds as to stability, intensity and duration of action. Ehrlich's concepts were the guiding principle in this work.

Hunt assumed that the blood pressure lowering action of acetylcholine and similar compounds was due mainly to a negative inotropic cardiac action. In 1914, Dale showed that acetylcholine (and certain other choline esters) caused a decrease of blood pressure from peripheral vasodilatation, and in addition that after atropine a rise of pressure resulted from large doses due to a "nicotine" type of action. Hunt frankly admitted his errors in two excellent papers on vasodilator reactions published in 1918. In these papers he confirmed Dale's previous work, but found great difficulty in explaining the vasodilator action of acetylcholine which was abolished by atropine. From these studies he concluded "the above experiments, and those of the preceding paper, show that there is widely distributed in at least certain animals a vasodilator mechanism which has not hitherto been clearly recognized in physiology, pharmacology or pathology; the outstanding features of it are (1) its ability to respond, with great energy, to a limited group of compounds of the cholin type and to pilocarpine and perhaps a few others; (2) that this action is prevented by atropine; and (3) that it apparently is not connected with any of the known vasodilator nerves. It seems appropriate to speak of a 'mechanism,' for different blood vessels react unequally, i.e., something other than the contractile elements of muscular tissue is involved, and because the action is prevented by atropine; the latter reaction is usually interpreted as indicating the presence of a 'nerve-ending' or of a 'receptive substance,' i.e., some kind of a 'mechanism.' "

The second field of work in which Hunt carried out investigations for many years was that of the physiology and pharmacology of the thyroid gland. His interest in this field also stems from his work with Ehrlich on the toxicity of and antidotes for nitriles. On the hypothesis that the toxicity of acetonitrile was due to a change to hydrocyanic acid partly by oxidation, he expected that the administration of thyroid gland by increasing basal metabolism should enhance the toxicity of the substance. In accord with his expectation, the lethal dose of acetonitrile for rats and guinea pigs decreased after several days administration of thyroid gland. On the other hand, mice reacted in the opposite way: they became very resistant to the poison. His first paper on this subject was published in 1905. For the next twenty years he employed this "acetonitrile reaction" in a series of extensive and painstaking studies of various problems in connection with the physiology and pharmacology of the thyroid gland. Some of the results of this work were: the detection of small amounts of thyroid substance, for which there were no satisfactory chemical methods; the correlation of physiological activity with the iodine content of the thyroid, upon which was based the pharmacopoeial standard for thyroid; the finding that iodides and certain kinds of diets markedly influence the function of the thyroid gland; and the observation that the physiological activity of thyroxin is less than that of dried thyroid gland when expressed in terms of iodine content. In addition to the above, very extensive studies on the influence of various diets on toxicity to various drugs, mainly acetonitrile, were made. Another interesting finding was that animals to which a "moderate" amount of ethyl alcohol had been administered for some time acquired an increased susceptibility to acetonitrile, the poison being more rapidly broken up in the body. This, as far as I know, is the only evidence available today of a physiological change from prolonged administration of small amounts of alcohol.

While in Ehrlich's laboratory during 1903, Hunt formed a close friendship with Christian A. Herter which was maintained until the latter's death in 1910. When Abel and Herter initiated the Journal of Biological Chemistry in 1905, one of their most valued consultants in that enterprise was Reid Hunt. Likewise, when the American Society for Pharmacology and Experimental Therapeutics and The Journal of Pharmacology and Experimental Therapeutics were initiated by Abel, Hunt was closely associated with him in both ventures. He did a great deal of the work necessary for the gathering of the charter members of the Society and was its first secretary.

Dr. Hunt was elected to the National Academy of Sciences in 1919.

No account of Hunt's work can be considered complete without reference to his most important activities in connection with the U. S. Pharmacopoeia and with the Council on Pharmacy and Chemistry of the American Medical Association. He was a member of the 1910 U. S. P. Revision Committee. In 1920, he was elected president of the United States Pharmacopoeial Convention, serving for the next decade. He realized the importance of the Pharmacopoeia in promoting standards of high purity and reliability for important drugs, and, also, that the pharmacopoeias of the world must assume an international character to truly represent the needs of the medical profession. He was appointed a member of the Permanent Standards Commission of the League of Nations Health Committee.

Hunt became a member of the Council on Pharmacy and Chemistry in 1906, only one year after its formation. He served for thirty years, the last nine of these as Chairman. There seems little doubt of the great service which Hunt rendered to the medical profession by his activities in these organizations. Hunt's successor as a member of the Council, recently stated: "Only the members who worked with him on the Council have an adequate appreciation of the enormous amount of time and labor that Reid Hunt put into the Council activities. As someone said, he made a vocation of a hobby. Many of the difficult reports published by the Council were prepared personally by Dr. Hunt. It is the type of work that does not receive the public recognition that it deserves, but certainly, he did a fine service to American Medicine. Throughout his active career, he always maintained an interest and a fair attitude toward pharmaceutical houses, and weighed their merits. I have heard it said, repeatedly, that few people have ever given nearly as much service to the Council as Dr. Hunt."

At the turn of the century, there was a small group of men who subjected themselves to a rigid and wide discipline in the fundamental sciences without losing their interest in medical problems. Reid Hunt was one of these. It was such men who carried a new spirit of fundamental research to American preclinical departments. Hunt gained a well deserved reputation as one of the pioneers in American pharmacology.

KEY TO ABBREVIATIONS USED IN BIBLIOGRAPHY

Amer. Jour. Phar.=American Journal of Pharmacy
Amer. Jour. Physiol.=American Journal of Physiology
Arch. Internal Med.=Archives of Internal Medicine
Arch. internat. pharm.=Archives internationales de pharmacodynamie
Arch. internat. physiol.=Archives internationales de physiologie
British Med. Jour.=British Medical Journal
Bull. Mass. Coll. Phar.=Bulletin of the Massachusetts College of Pharmacy
Centr. Physiol.=Centralblatt für Physiologie
Ind. Eng. Chem.=Industrial and Engineering Chemistry
Johns Hopkins Hosp. Bull.=Johns Hopkins Hospital Bulletin
Jour. Amer. Med. Assn.=Journal of the American Medical Association
Jour. Amer. Pharm. Assn.=Journal of the American Pharmaceutical Association
Jour. Biol. Chem.=Journal of Biological Chemistry
Jour. Exper. Med.=Journal of Experimental Medicine
Jour. Pharm. Exper. Therap.=Journal of Pharmacology and Experimental Therapeutics
Jour. Physiol.=Journal of Physiology
New Eng. Jour. Med.=New England Journal of Medicine
Quart. Jour. Inebriety=Quarterly Journal of Inebriety

BIBLIOGRAPHY OF REID HUNT

1895

The Fall of Blood-Pressure Resulting from the Stimulation of Afferent Nerves. Jour. Physiol., *18:* 381-410.

1897

(With D. W. Harrington) Innervation of Heart of Opossum. Science, N.S. *5:* 906.

Some Experiments on the Lobster's Heart. I. (With Messrs. Bookman and Tierney) Some General Properties of the Cardiac Muscle of the Lobster. II. (With Messrs. Lyman and Williams) The Effect of Changes of Temperature upon the Lobster's Heart. Science, N.S. *5:* 907.

Experiments on the Relation of the Inhibitory to the Accelerator Nerves of the Heart. Jour. Exper. Med., *2:* 151-179.

(With D. W. Harrington) Notes on the Physiology of the Cardiac Nerves of the Opossum (Didelphys Virginiana). Jour. Exper. Med., *2:* 711-721.

(With D. W. Harrington) Note on the Physiology of the Cardiac Nerves of the Calf. Jour. Exper. Med., *2:* 723-727.

(With A. Bookman and M. J. Tierney) Einige allgemeine Eigenschaften des Herzmuskels vom amerikanischen Hummer (Homarus Americanus). Centr. Physiol., *11:* 274-278.

1899

Direct and Reflex Acceleration of the Mammalian Heart. Amer. Jour. Physiol., *2:* ix-x.

Direct and Reflex Acceleration of the Mammalian Heart, with Some Observations on the Relations of the Inhibitory and Accelerator Nerves. Amer. Jour. Physiol., *2:* 395-470.

Note on a Blood-Pressure Lowering Body in the Suprarenal Gland. Amer. Jour. Physiol., *3:* xviii.

1901

Further Observations on the Blood-Pressure-Lowering Bodies in Extracts of the Suprarenal Gland. Amer. Jour. Physiol., *5:* vi.

On the Effects of Intravenous Injections of Minimal Doses of Epinephrin Sulphate upon the Arterial Blood-Pressure. Amer. Jour. Physiol., *5:* vii.

1902

Experiments with Zygadenus venenosus (Poison Camass). Amer. Jour. Physiol., *6:* xix.

The Toxicity of Methyl Alcohol. Johns Hopkins Hosp. Bull., *13:* 213-225.

1904

Zur Kentniss der Toxikologie einiger Nitrile und deren Antidote. Arch. internat. pharm., *12:* 447-495.

Ueber die Toxicität einiger Chinin-Derivate. Arch. internat. pharm., *12:* 497-505.

1905

(With Murray Galt Motter) Changes in the Pharmacopoeia of the United States of America. Eighth decennial revision. U. S. Hygienic Laboratory, Bull. 23.

The Influence of Thyroid Feeding upon Poisoning by Acetonitrile. Jour. Biol. Chem., *1:* 1-12.

1906

(With R. de M. Taveau) On the Physiological Action of Certain Cholin Derivatives and New Methods for Detecting Cholin. British Med. Jour., *2:* 1788-1791.

The Comparative Physiologic Activity of Some Commercial Suprarenal Preparations. Jour. Amer. Med. Assn., *47:* 790-792.

1907

Studies in Experimental Alcoholism. U. S. Hygienic Laboratory, Bull. 33.

The Probable Demonstration of Thyroid Secretion in the Blood in Exophthalmic Goiter. Jour. Amer. Med. Assn., *49:* 240-241.

The Relation of Iodin to the Thyroid Gland. Jour. Amer. Med. Assn., *49:* 1823-1829.

Iode et glande thyroïde (On the relation of iodine to the thyroid gland). VII^e^ Congrès international de physiologie, Heidelberg, 1907. Arch. internat. physiol., *5:* 105-106.

Isopral and Chloral Hydrate. Comments on the Above Criticisms by Impens. Jour. Amer. Med. Assn., *49:* 1906-1912.

1908

The Loco-weed Disease. Science, *28:* 570-571.

(With A. Seidell) Commercial Thyroid Preparations and Suggestions as to the Standardization of Thyroid. Jour. Amer. Med. Assn., *51:* 1385-1388.

1909

(With A. Seidell) Studies on Thyroid. I. The Relation of Iodine to the Physiological Activity of Thyroid Preparations. U. S. Hygienic Laboratory, Bull. 47.

(With A. Seidell) Howell's Mercol. Jour. Amer. Med. Assn., *52:* 225.

Report on the Twelfth International Congress on Alcoholism, and the Sixteenth International Medical Congress. Public Health Reports, *24:* No. 41, pp. 1487-1490.

What the Individual Physicians Can Do to Improve the Materia Medica. Jour. Amer. Med. Assn., *53:* 497-502.

(With R. de M. Taveau) On the Relation between the Toxicity and Chemical Constitution of a Number of Derivatives of Choline and Analogous Compounds. Jour. Pharm. Exper. Therap., *1:* 303-339.

The Effects of Inanition and of Various Diets upon the Resistance of Animals to Certain Poisons. Jour. Biol. Chem. (Proceedings) *7:* xxix.

1910

Some Problems of Pharmacopoeial Revision. Jour. Amer. Med. Assn., *54:* 173-175.

The Effects of a Restricted Diet and of Various Diets upon the Resistance of Animals to Certain Poisons. U. S. Hygienic Laboratory, Bull. 69.

(With A. Seidell) Thyreotropic Iodine Compounds. Jour. Pharm. Exper. Therap., *2:* 15-47.

(With R. de M. Taveau) Pharmacopoeial Action of a Number of Cholin Derivates and Analogous Compounds. XVI International Medical Congress, Budapest, Section V, 2^me^ fascicule, p. X, 1910.

Pharmacopoeial Preparations of the Thyroid Gland. XVI International Medical Congress, Budapest, Section V, 2^me^ fascicule, p. XXVII, 1910.

Report of the Proceedings of the Tenth International Congress of Pharmacy, Brussels, September 1-6, 1910. Public Health Reports, *25:* No. 40, pp. 1406-1408.

Second International Conference for the Study of Cancer (Paris, October 1-5, 1910) and Ninth International Antituberculosis Conference (Brussels, October 5-8, 1910). Public Health Reports, *25:* No. 45, pp. 1624-1626.

1911

(With R. de M. Taveau) The Effects of a Number of Derivatives of Choline and Analogous Compounds on the Blood-Pressure. U. S. Hygienic Laboratory, Bull. 73.

Experiments on the Relation of the Thyroid to Diet. Jour. Amer. Med. Assn., *57:* 1032-1038.

(With A. Seidell) The Pharmacopoeial Standard for Desiccated Thyroid Glands. Amer. Jour. Phar., *83:* 407-411.

1912

(With A. Seidell) The Pharmacopoeial Standard for Desiccated Thyroid Glands. Jour. Amer. Pharm. Assn., *1:* 131-133.

1913

Restriction of the Use of Alcohol by Employees of Common Carriers in the United States and Europe. Quart. Jour. Inebriety, *34:* 198-201.

1915

The Physician and Proprietary Medicines. Bull. Mass. Coll. Phar., 16-24.

Some Physiological Actions of the Homocholins and of Some of Their Derivatives. Jour. Pharm. Exper. Therap., *6:* 477-525.

A Physiological Test for Cholins and Some of Its Applications. Jour. Pharm. Exper. Therap., *7:* 301-337.

1918

Vasodilator Reactions. I. Amer. Jour. Physiol., *45:* 197-230.

Vasodilator Reactions. II. Amer. Jour. Physiol., *45:* 231-267.

1921

Some Factors Relating to the Toxic Action of Arsphenamin. Jour. Amer. Med. Assn., *76:* 854-859.

1923

The Acetonitril Test for Thyroid and of Some Alterations of Metabolism. Amer. Jour. Physiol., *63:* 257-299.

The Comparative Physiological Activity of Thyroid and Thyroxin. Jour. Pharm. Exper. Therap. (Proceedings), *21:* 199.

1924

Glandular Therapy; Pharmacology of Thyroid Substance. Jour. Amer. Med. Assn., *83:* 1244-45.

1925

Bioassay of Thyroids. Public Health Reports, *40:* 1461-1466.

Standardization of Thyroid Preparations. Arch. Internal Med., *35:* 671-686.

Standardization of Thyroid. Jour. Pharm. Exper. Therap. (Proceedings), *25:* 138-139.

(With R. R. Renshaw) Some Effects of Arsonium, Sulfonium, and Analogous Compounds on the Autonomic Nervous System. Jour. Pharm. Exper. Therap., *25:* 158-159.

(With R. R. Renshaw) On Some Effects of Arsonium, Stibonium, Phosphonium and Sulfonium Compounds on the Autonomic Nervous System. Jour. Pharm. Exper. Therap., *25:* 315-355.

1926

Some Effects of Quarternary Ammonium Compounds on the Autonomic Nervous System. Jour. Pharm. Exper. Therap., *28:* 367-388.

(With R. R. Renshaw) Some Effects of Betaine Esters and Analogous Compounds on the Autonomic Nervous System. Jour. Pharm. Exper. Therap., *29:* 17-34.

1927

(With William S. McCann, L. G. Rowntree, Carl Voegtlin, and Cary Eggleston) The Status of Intravenous Therapy. Jour. Amer. Med. Assn., *88:* 1798-1802.

1928

(With William S. McCann, L. G. Rowntree, Carl Voegtlin, and Cary Eggleston) The Status of Intravenous Therapy. Jour. Amer. Med. Assn., *90:* 764-767.

An Examination of the Toxicity of One Hundred Samples of Illicit Liquor. New Eng. Jour. Med., *198:* 230-234.

(With William S. McCann, L. G. Rowntree, Carl Voegtlin, and Cary Eggleston) The Status of Intravenous Therapy. V. (with Kenneth F. Maxcy) Limitations to the Use of Quinine Intravenously in the Treatment of Malaria. Jour. Amer. Med. Assn., *91:* 1372-1375.

1929

Standardization of Thyroid Preparations. Leopoldina, *4:* 32-45.

(With R. R. Renshaw) Some Effects of Derivatives of Betaine Amide and of Choline Ethers on the Autonomic Nervous System. Jour. Pharm. Exper. Therap., *35:* 99-128.

(With R. R. Renshaw) Action of Certain Heterocyclic Compounds on the Autonomic Nervous System. Jour. Pharm. Exper. Therap., *35:* 75-98.

(With R. R. Renshaw) Further Studies on the Relation of Heterocyclic Compounds to the Autonomic Nervous System. Jour. Pharm. Exper. Therap., *37:* 177-191.

(With R. R. Renshaw) Ethers of Formocholine and Choline. Jour. Pharm. Exper. Therap., *37:* 193-202.

(With William S. McCann, L. G. Rowntree, Carl Voegtlin, and Cary Eggleston) The Status of Intravenous Therapy. Jour. Amer. Med. Assn., *92:* 2099-2101.

(With R. R. Renshaw) The Physiological Action of Some Homologues of Betaine and Choline Esters. Jour. Pharm. Exper. Therap., *37:* 309-337.

1930

President's Address. Delivered by President Reid Hunt at the 1930 United States Pharmacopoeial Convention, Tuesday, May 13, 1930, in Washington, D. C.

Promotion of Medicine and Pharmacy. Science, *72:* 49-58.

Opportunities. The Nucleus, November.

1931

Chemistry and Medicine. The Nucleus, March.

The Safer Way Is the Better Way. New Eng. Jour. Med., *205:* 314.

1932

(With R. R. Renshaw) Sulfonium Compounds and the Autonomic Nervous System. Jour. Pharm. Exper. Therap., *44:* 63-79.

(With R. R. Renshaw) Thio and Thiomethyl-Ammonium Compounds. Jour. Pharm. Exper. Therap., *44:* 151-169.

Toxicity of Ethylene and Propylene Glycols. Ind. Eng. Chem., *24:* 361.

1933

(With R. R. Renshaw) Effects of Some Quaternary Ammonium and Analogous Compounds on the Autonomic Nervous System. Jour. Pharm. Exper. Therap., *48:* 51-66.

(With R. R. Renshaw) Ethers and Thio-Ethers of Triethylammonium Compounds. Jour. Pharm. Exper. Therap., *48:* 105-125.

1934

(With R. R. Renshaw) Further Studies of Methyl Cholines and Analagous Compounds. Jour. Pharm. Exper. Therap., *51:* 237-262.

Note on Acetyl-β-methyl Choline. Jour. Pharm. Exper. Therap., *52:* 61-69.

1935

Notes on Acetyl-Methyl-Choline. Jour. Pharm. Exper. Therap., *55:* 268-273.

1936

(With R. R. Renshaw) Ethers of Choline and Allied Compounds. Jour. Pharm. Exper. Therap., *58:* 140-154.

Note on Methyl Cholines. Jour. Pharm. Exper. Therap., *58:* 328-331.

CONTRIBUTIONS TO BOOKS

(With Walter Jones) Physiological Chemistry (Reviews) In The American Year-Book of Medicine and Surgery. Edited by George M. Gould. Published by W. B. Saunders.

1900 Volume *Medicine,* p. 562-583
1901 Volume *Medicine,* p. 612-634
1902 Volume *Medicine,* p. 648-672
1903 Volume *Medicine,* p. 638-661
1904 Volume *Medicine,* p. 601-634
1905 Volume *Medicine,* p. 620-656

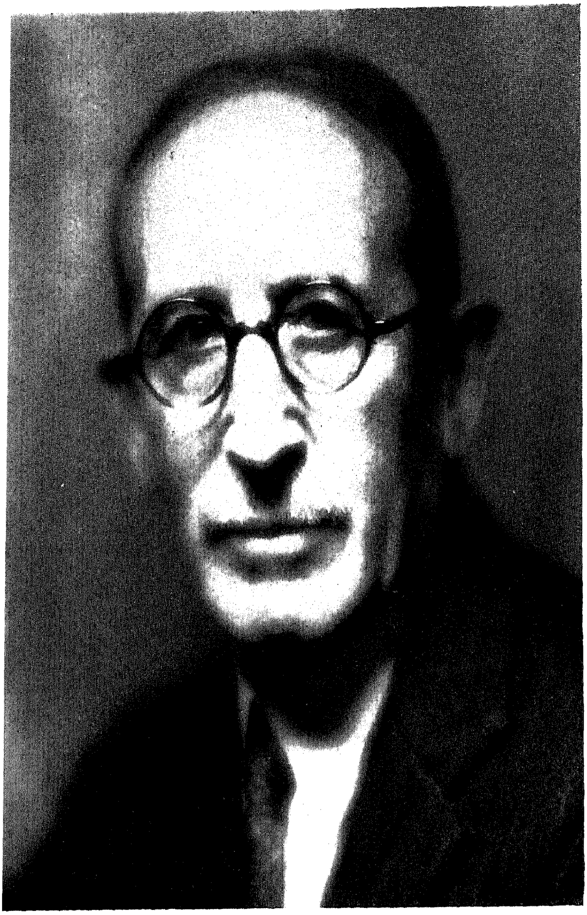
Cardiac Depressants, and Stimulants—Cholin—Chyle—Chyme—Jecorin—Lecithin—Neurin. Volumes *2, 3, 5* and *6* in A Reference Handbook of the Medical Sciences. A new ed., completely revised and rewritten, ed. by Albert H. Buck . . . New York, W. Wood and Company, 1900-1908.

(With Walter Jones) Non-Alkaloidal Organic Poisons. In A Text-Book of Legal Medicine and Toxicology. Edited by Frederick Peterson and Walter S. Haines. Vol. *2:* 532-643. W. B. Saunders and Co., Philadelphia, New York, and London, 1904.

Organotherapeutics. In Therapeusis of Internal Diseases, *1:* 66-124, Edited by Frederick Forschheimer. New York and London, D. Appleton and Company, 1913.

Cyanwasserstoff, Nitrilglucoside, Nitrile, Rhodanwasserstoff, Isocyanide. In Handbuch der experimentellen Pharmakologie. Edited by A. Heffter. *1:* 702-832. Berlin, Verlag von Julius Springer, 1923.

(With Alexander O. Gettler) Non-Alkaloidal Organic Poisons. In Legal Medicine and Toxicology, 2nd edition, vol. *2:* 602-771. Edited by Frederick Peterson, Walter S. Haines, and Ralph W. Webster. Philadelphia and London, W. B. Saunders Company, 1923.



JAMES EWING

1866–1943

BY JAMES B. MURPHY

The name of James Ewing is inseparably connected with the development of two important institutions. As the Professor of Pathology at Cornell Medical College and the only full-time professor in the early period, it was said that the development of the College was a reflection of the principles and mannerisms of James Ewing. The other institution was the Memorial Hospital (New York) where he was pathologist for many years. To quote from a statement of an associate, "The relationship of Ewing to the Memorial Hospital can best be expressed in the words of Emerson, 'Every institution is but the lengthening shadow of some man.' Dr. Ewing is the Memorial Hospital"—(Adair). His very great influence was effected, in both instances, without a formal authoritative position, for he was neither Dean of the Cornell Medical College nor Director of Memorial Hospital during their formative years.

James Ewing was born in Pittsburgh on Christmas day 1866. His father, Thomas, came from a staunch Scotch, Scotch-Irish, Presbyterian family, of whom it was said "had produced men whose intellect and energy had helped mold the institutions of wherever they settled." Thomas Ewing, after graduation from Jefferson College, became a teacher, and continued in this profession until he was 36 years of age. He then studied law and became a judge in the Court of Common Pleas in Pittsburgh, a position he held until his death at 69 years of age. He was considered a leading citizen of that city, was an elder of the Presbyterian Church and a director of the Theological Seminary. In characterizing his father, James Ewing wrote, "If I had any hereditary bents they were intensified by the example of my father of whom I may only say he was a man of tireless energy, pure intellect and complete self effacement."

Dr. Ewing's mother, Julia Hufnagel, of Stockbridge, Massachusetts, was of German ancestry. She graduated in the first class from Mt. Holyoke College, and she also became a teacher. Her favorite pursuits outside her educational activities were music and social work.

Thus, James Ewing grew up in a rather stern, intellectual and religious environment. He was known as a sensitive boy, mentally alert, inquisitive, and adventurous. He was physically active, intensely interested in sports, an interest he retained throughout life. It was said of him that everything he attempted he did with furious attention. When he was 12 years old he collected and mounted butterflies and his collection was of such excellence that it became a permanent exhibition in a Pittsburgh museum. It was at about the same period that he acquired a microscope and became deeply immersed in the study of insects, thus early starting microscopy, which was destined to be his major life work. At 14 he developed osteomyelitis of the femur from which he was bedridden for two years, and this was followed by a longer period of intense suffering and invalidism, that left him a permanent cripple.

During this bedridden period his instruction was continued by a tutor, and he was developing an outstanding quality that was prominent through his educational period, namely receptiveness to mental training. Ewing attributed his no small talent in the use of language to the influence of his tutor, who had "a marvelous way in which he balanced delicate shades of meaning in Latin and Greek phrases." Exercise of this facility was considered by Ewing as a lesson in close thinking and it made a permanent impression on his own mental processes. By the time he entered Amherst College in 1884, he was able to read both Latin and Greek poetry at sight.

At Amherst he was fortunate to come under the influence of Charles Edward Garman, Professor of Philosophy, who did much to help Ewing free himself of self-consciousness and a feeling of inferiority from his infirmity. He developed an ardent interest in sports, and in spite of his lameness became a good tennis player. He graduated from Amherst in 1888 and was elected to Phi Beta Kappa the same year.

In the fall of 1888 he entered the College of Physicians and Surgeons of New York and was in the first class to graduate after this institution had become affiliated with Columbia University. Little is recorded of his medical school period except his remark that "I ran headlong into that rare personality, T. Mitchell Prudden, and to him I owe my main tendencies and conceptions as a physician and as a pathologist. At the time I was wearing a Phi Beta Kappa key that seemed as large as a cow bell and at the same time a certain weight of self esteem. I soon lost both of them." It is certain that during these years he developed a keen interest in pathology, evidenced by his expressed belief that the pursuit of problems in a pathological laboratory is the choicest field in medicine. He spent much time in the hospital laboratory during his clinical internship at Roosevelt Hospital and produced his paper entitled "A Study of the Leucocytosis of Lobar Pneumonia." It was also during this period that his interest in the blood developed, which eventually led to his first book, Clinical Pathology of the Blood (1901).

The years immediately following the completion of Ewing's internship (1893-98) were restless ones. As there were few academic or research positions that paid a living wage, Ewing felt forced to enter private practice, but he continued his interest in the scientific side of medicine. He held such positions as Tutor in Histology—Columbia University, 1893-97; Clark Fellow—Columbia University, 1896-99; Instructor of Clinical Pathology, 1897-98; and spent a period in the study of pathology in Europe. It soon became evident that the practice of medicine was not his forte, and this effort was abandoned in 1898 when, during the Spanish-American War, he became a Contract Surgeon in the Army and was assigned to Camp Wikoff. Here his thirst for knowledge soon led him into an investigation of malaria, and he published several papers on this subject.

In 1899 he was appointed Professor of Pathology in the newly organized Cornell University Medical College, where, as the only full-time professor, as already noted, he exerted considerable influence on the development of this institution. He proved to be a prodigious worker and a forceful, stimulating teacher. He was profoundly affected by the death of his young wife, after less than three years of marriage, from a complication of pregnancy. Following this he became even more absorbed in work, and his interest in the pathogenesis of the group of conditions related to the toxemias of pregnancy became almost an obsession.

The focussing of his interest upon cancer may be traced to the establishment by Mrs. Collis P. Huntington of the C. P. Huntington Fund for Cancer Research in 1902. It was stipulated that the income from this Fund be expended for cancer research in the Loomis Laboratory, associated with Cornell Medical College, under the direction of Dr. Ewing. One of his few investigations based on animal experimentation was published during the early years of administration of this Fund. However, he gave much time and attention to the direction of the work, which served to enhance his reputation as an authority on cancer, and he soon became known as the outstanding cancer pathologist in New York.

By 1910 some 50 papers had been published from the Loomis Laboratory on cancer, under the support of the Huntington Fund. By this time Ewing had arrived at the conviction that the best hope for advancing knowledge in cancer was to study the disease in man, a conviction that he held throughout his life. He proposed a plan to the New York Hospital by which a commission was to be set up to carry out clinical cancer study in a general hospital. The first contact with Dr. James Douglas, who was destined to play a leading role in Ewing's future, was made through this Cancer Commission. The development of the New York Hospital plan evidently ran into difficulties for soon Ewing recommended that the project be suspended until larger facilities and more complete organization could be provided. With the financial backing of Dr. Douglas, Ewing approached the Memorial Hospital with a proposal for the assignment of a certain number of beds for the clinical study of cancer. This institution, organized in 1884 as a cancer hospital, had found difficulty in maintaining its status as such. By 1912 Dr. Douglas had given $100,000 for the endowment of 20 beds for clinical research work, and equipment for an X-ray plant and clinical laboratory. Dr. Douglas, a mineralogist and mining engineer, was an enthusiast with definite convictions and was considered by many as the most gifted and many sided man of his time. He undoubtedly had considerable influence on Ewing in the development of the Memorial Hospital and was certainly responsible for the interest in radio therapy developed by this institution. In 1913 he took Ewing on a tour of Europe to investigate the use of radium as a therapeutic agent in cancer, and later, with Dr. Howard Kelley, financed the production of radium in this country. Dr. Douglas's share of the output was donated to the Memorial Hospital.

When Ewing took up his work as pathologist to the Memorial, he held several strong opinions: first, as already noted, he believed that cancer research should be centered around the cancer patient. He did not believe that surgery was the final answer to the problem but that other methods of treatment must be assiduously pursued. He espoused the idea of special cancer hospitals and the concept of the disease as a medical specialty. Needless to say, his point of view was bitterly criticized by a section of the medical profession. Nevertheless he did bring the Memorial Hospital back from being simply another general hospital to the original intentions of its founders and he succeeded in attracting able men into the field as cancer specialists. His determination to establish the possibilities and limitations of X-ray and radium therapy was also criticized by some leaders in the profession as unjustified human experimentation. But Ewing pursued his course unperturbed, and today, while there is not universal acceptance, the idea of special cancer hospitals and of cancer as a medical specialty has been widely adopted.

With the Douglas backing, Ewing gained a foothold in Memorial Hospital which he developed through the force of his personality to a point where it was said in 1912 that he had assumed full responsibility for the direction of its policies, though his official position was only that of pathologist to the institution. Under his guidance the Memorial Hospital attained a worldwide recognition. The department of pathology had a long and distinguished record of leadership in the clinical classification and the diagnostic histology of tumors. It became an outstanding educational center to which surgeons and pathologists were drawn from many parts of the world to acquire concentrated experience and instruction in the diagnosis and classification of the many forms of cancer.

In 1931, on Ewing's retirement as Professor of Pathology at Cornell Medical College, he was made full-time director of Memorial Hospital, thus acquiring the title for a position he had held through his personality for many years. In 1939, at 73 years of age, he retired as Director and became Consulting Pathologist.

Ewing's influence was by no means confined to the two institutions he served so handsomely. Through his interest in research he was one of the organizers of the American Association for Cancer Research and served many terms as officer and council member. Through his discussions and constructive criticisms of the papers presented at the meetings he contributed in no small way to the raising of the standard of cancer research in this country. He was also one of the founders of the American Society for the Control of Cancer (now American Cancer Society) in 1913, served in various offices, and was on the governing board for more than 30 years. During his long years of association, he prepared or edited a large part of the popular educational material distributed by the Society. His prestige did much to secure the acceptance by the medical profession of the idea of lay education for the recognition of early signs and symptoms of cancer. His passion for truth and integrity led him to oppose bitterly the inclusion in the publications or slogans of the Society any statement or figures that could be construed as misleading by a hair's breadth.

Few men have endured as much physical suffering as Ewing did during his life: first, as noted above, from osteomyelitis that left him a permanent cripple at 14 years of age, for years intense suffering from trifacial neuralgia, later in life urinary calculosis, and finally cancer of the bladder. The loss of his young wife after less than three years of marriage had a profoundly saddening effect upon his life. It was said of him that adversity, suffering, disappointment, and sorrow left their mark on him not in the form of bitterness or disillusionment but in increasing sensitiveness for the misfortune of others. "His sympathy and kindliness became almost legendary during his lifetime and the very legend of his benignity impressed itself on his character"—(Stewart). That this benignity was not of the mere sentimental variety was shown by his intolerance of sham, hypocrisy, and mental laziness, which led him to be an unsparing critic.

Perhaps his most important contribution was his book, Neoplastic Diseases, first published in 1919. In regard to this publication, an associate records that "for ten years Ewing worked with zealous ardor, holidays, nights, week ends, stopping for minutes only to fight the paroxysms of tic douloreux." This book immediately became the standard reference and textbook of the world and has continued to hold this position, through its several editions, for the 30 years since its first publication. His discrimination in estimating scientific contributions and his ability to coordinate new facts gave high value to his occasional publications or lectures. Those in which he placed current contributions in proper perspective were masterpieces of clarity and critical analysis.

While Ewing is known best as a cancer pathologist, Dr. William H. Welch called attention to the fact that there was scarcely a domain in pathology which he did not cultivate, were it morphological, chemical, clinical or experimental. He referred to Ewing as an eminent scholar, an eminent trainer of scholars, an international leader in pathology. Among the chief fields of investigation may be mentioned the following: leucocytosis in disease, 1895; ganglion cells, 1896; status lymphaticus, 1895, 1918; malaria, 1897-99; diseases of the blood, 1899-1902; variola, 1901-03; toxemia of pregnancy, 1904-07; cancer, 1895-1939.

Ewing was an outspoken opponent of the idea that there could be an all-embracing cause or cure for cancer, maintaining that cancer does not represent a single disease but is a generic term covering a broad department of biology and a universal potentiality of tissue cells. He was an experimenter, not in the narrow sense of the pure laboratory worker, but in the field of human experiment. In the early days every patient subjected to treatment by X-rays, radium or by various biologic products constituted an experiment. These were by no means always encouraging but they nevertheless yielded new data, piling up references for future modifications, with possibly larger promise towards success. To him are attributed three of the most important developments in the cancer field: the modern cancer hospital, cancer clinic, and public health cancer program.

"He himself succumbed to the disease toward the solution and early diagnosis of which the major portion of his life had been devoted. Signs of a benign disease from which he had suffered for years, yet which had disappeared after appropriate treatment, recurred with but little change and hence failed to announce the onset of a totally new disease until the latter was far advanced and hopeless"—(Stewart).

As an indication of the respect in which Ewing was held, the following memorials have been established in the short time since his death: the Ewing Professorship in Neoplastic Diseases, at Cornell Medical College; the Ewing Memorial Fund, which supports two annual lectureships and undergraduate student training in tumor pathology; the James Ewing Hospital, a 300-bed City hospital for cancer patients.

Dr. Ewing was elected to the National Academy of Sciences in 1935. He died on May 16, 1943.

Much of the material in regard to Dr. Ewing's background and early life was obtained from an extensive file of information collected by Dr. Hayes Martin. The author gratefully acknowledges his indebtedness to Dr. Martin for the use of this valuable material.

KEY TO ABBREVIATIONS USED IN BIBLIOGRAPHY

Am. J. Med. Sci. = American Journal of the Medical Sciences
Am. J. Obst. = American Journal of Obstetrics
Am. J. Path. = American Journal of Pathology
Am. J. Roent. = American Journal of Roentgenology
Am. J. Surg. = American Journal of Surgery
Am. Soc. Cont. Cancer = American Society for the Control of Cancer
Ann. Surg. = Annals of Surgery
Arch. Int. Med. = Archives of Internal Medicine
Arch. Neurol. Psychopath. = Archives of Neurology and Psychopathology
Arch. Path. = Archives of Pathology
Arch. Surg. = Archives of Surgery
Brit. Med. J. = British Medical Journal
Bull. Internatl. Assn. Med. Mus. = Bulletin of the International Association of Medical Museums
Bull. N. Y. Acad. Med. = Bulletin of the New York Academy of Medicine
Canad. J. Med. Surg. = Canadian Journal of Medicine and Surgery
Canad. Lancet Pract. = Canadian Lancet and Practitioner
Canad. Med. Assn. J. = Canadian Medical Association Journal
Canad. Pract. = Canadian Practitioner
J. Am. Med. Assn. = Journal of the American Medical Association
J. Cancer Res. = Journal of Cancer Research
J. Exp. Med. = Journal of Experimental Medicine
J. Infect. Dis. = Journal of Infectious Diseases
J. Med. = Journal of Medicine
J. Med. Res. = Journal of Medical Research
J. Nerv. Ment. Dis. = Journal of Nervous and Mental Disease
Med. News = Medical News
Med. Officer = Medical Officer
Med. Rec. = Medical Record
Mil. Surg. = Military Surgeon
Mo. Bull. N. Y. State Dept. Health = Monthly Bulletin of the New York State Department of Health
N. Y. Med. J. = New York Medical Journal
N. Y. State J. Med. = New York State Journal of Medicine
Pittsburgh Med. Rev. = Pittsburgh Medical Review
Proc. Ann. Cong. Med. Ed. = Proceedings of the Annual Congress on Medical Education
Proc. Assn. Am. Med. Coll. = Proceedings of the Association of American Medical Colleges
Proc. N. Y. Path. Soc. = Proceedings of the New York Pathological Society
Proc. Path. Soc. Phila. = Proceedings of the Pathological Society of Philadelphia
Pub. Health Rep., U. S. P. H. S. = Public Health Report of the United States Public Health Service
Rev. Gastroenterol. = Review of Gastroenterology
Surg., Gynec. Obst. = Surgery, Gynecology and Obstetrics

Trans. Assn. Am. Physn. = Transactions of the Association of American Physicians
Trans. Coll. Physn. Phila. = Transactions of the College of Physicians of Philadelphia
Virchow's Arch. = Virchow's Archiv für pathologische anatomie und physiologie und klinische medizin

BIBLIOGRAPHY OF JAMES EWING

1892

The Syms operating building of the Roosevelt Hospital. Pittsburgh Med. Rev., *6*, 362.

1893

A study of the leucocytosis of lobar pneumonia. N. Y. Med. J., *58*, 713.

1894

Guanin gout in the hog. Proc. N. Y. Path. Soc., p. 107.
Occlusion of the ileocaecal valve by a plug of mucus. Extreme interstitial emphysema of the lungs. Proc. N. Y. Path. Soc., pt. 2, p. 43.
Lipomatosis of the heart. Proc. N. Y. Path. Soc., pt. 2, p. 89.
Rupture of the bladder and peritonitis. Proc. N. Y. Path. Soc., pt. 2, p. 106.

1895

The leucocytosis of diphtheria under the influence of serum therapy. N. Y. Med. J., *62*, 161.
Toxic hypoleucocytosis. N. Y. Med. J., *61*, 257.
Acute infectious disease with intestinal lesions. Proc. N. Y. Path. Soc., p. 22.
Hydronephrosis (two cases). Proc. N. Y. Path. Soc., p. 60.
Rupture of the bladder and peritonitis. Med. Rec., *47*, 282.

1896

(With P. Bailey) A contribution to the study of acute ascending (Landry's) paralysis. N. Y. Med. J., *64*, 1; J. Nerv. Ment. Dis., *23*, 316.
Rupture of the aorta. Proc. N. Y. Path. Soc., p. 18.
Primary pernicious anaemia. Proc. N. Y. Path. Soc., p. 59.
Bacillus aërogenes capsulatus. Proc. N. Y. Path. Soc., p. 111.

1897

The lymphatic constitution and its relation to some forms of sudden death. N. Y. Med. J., *66*, 37.
Total thrombosis of the left pulmonary artery. Proc. N. Y. Path. Soc., p. 11.
Adenoma of the kidney; total thrombosis of the vena cava. Proc. N. Y. Path. Soc., p. 26.
Subglottic abscess: death from oedema of the glottis. Proc. N. Y. Path. Soc., p. 68.
Filaria sanguinis stained. Proc. N. Y. Path. Soc., p. 69.

1898

Notes on clinical diagnosis (J. T. Doherty, N. Y.).

Studies on ganglion cells: a preliminary communication. Proc. N. Y. Path. Soc., p. 112; Med. Rec., *53*, 513.

Studies on ganglion cells. Arch. Neurol. Psychopath., *1*, 263.

The differential diagnosis by means of blood examination between tropical and malarial fevers and typhoid fever, including their etiology, prevention and treatment. Med. Rec., *54*, 494.

Comparative morphology of malarial plasmodia. Med. News, *73*, 782.

(With W. H. Thomson) A case of acute leukaemia. Med. Rec., *53*, 333.

(With A. Jacobi) Septic perforation of the right internal carotid artery: autopsy five months after death. Trans. Assn. Am. Physn., *13*, 326.

A case showing the bothriocephalus latus. Proc. N. Y. Path. Soc., p. 80.

Malignant adenoma of the stomach. Proc. N. Y. Path. Soc., p. 136.

Leukaemia. Proc. N. Y. Path. Soc., p. 137.

Demonstration of some noteworthy forms and combinations of malarial parasites observed at Camp Wikoff. Proc. N. Y. Path. Soc., p. 229.

1899

Preliminary report on the results of blood examinations at Camp Wikoff, August and September, 1898. N. Y. Med. J., *69*, 114, 149.

Papilloma of the larynx: suffocation. Proc. N. Y. Path. Soc., p. 94.

Tuberculous ulcer at the base of the epiglottis. Proc. N. Y. Path. Soc., p. 97.

General miliary tuberculosis: thrombosis of superior mesenteric artery. Proc. N. Y. Path. Soc., p. 97.

1901

Clinical pathology of the blood (Lea Brothers and Co., Phila. Ed. 1, 1901; ed. 2, 1903).

Conjugation in the asexual cycle of the tertian malarial parasite. N. Y. Med. J., *74*, 145.

Malarial parasitology. J. Exp. Med., *5*, 429.

A case of malarial nephritis with massing of parasites in the kidney. Am. J. Med. Sci., *122*, 426; Trans. Assn. Am. Physn., *16*, 450.

Remarks on the origin of "colloid carcinoma of the peritoneum." Proc. N. Y. Path. Soc., n.s., *1*, 11.

(With W. Coleman) A case of glanders in the human subject. Proc. N. Y. Path. Soc., n.s., *1*, 103.

1902

Contribution to the pathological anatomy of malarial fever. J. Exp. Med., *6*, 119.

The present status of serum therapy in typhoid fever. Med. News, *80*, 577.

Preliminary report on a study of smallpox. Trans. Assn. Am. Physn., *17*, 208.

Schmaus, Hans: A textbook of pathology and pathological anatomy. (Edited by James Ewing) (Lea Brothers and Co., Phila.).

Vaccine bodies in variola. Proc. N. Y. Path. Soc., n.s., *2*, 59.

The relation of streptococcus pyogenes to variola. Proc. N. Y. Path. Soc., n.s., *2*, 72.

A case of mixed quartan and aestivo-autumnal malaria: a meningocele. Proc. N. Y. Path. Soc., n.s., *2*, 116.
Demonstration of hemosiderin reaction in corneal vaccine bodies. Proc. N. Y. Path. Soc., n.s., *2*, 151.
(With I. Strauss) Limits of a specific reaction in the serum test for blood. Proc. N. Y. Path. Soc., n.s., *2*, 152.

1903

(With I. Strauss) Precipitins and their medicolegal use. Med. News, *83*, 871, 925.
(With W. Coleman) A case of septicemic glanders in the human subject. J. Med. Res., *9*, 223.
Differentiation of monkey and human blood by the serum test. Proc. N. Y. Path. Soc., n.s., *3*, 14.
"Identity," *in* Legal Medicine and Toxicology (Ed. by Peterson and Haines) (W. B. Saunders and Co., Phila.) *1*, 62. "The signs of death," ibid., p. 104. "Sudden death," ibid., p. 138.

1904

Comparative histology of vaccinia and variola. J. Med. Res., *12*, 509.
Comparative morphology of vaccine bodies. Proc. N. Y. Path. Soc., n.s., *3*, 203.

1904-1905

The structure of vaccine bodies in isolated cells. J. Med. Res., *13*, 233.

1905

Syllabus of lectures on inflammation and associated conditions. Monograph.
Some aspects of the problem of immunity in typhoid fever. Proc. Path. Soc. Phila., *8*, 65.
The pathological anatomy and pathogenesis of the toxemia of pregnancy. Am. J. Obst., *51*, 145.

1905-1906

Observations of spirochaetae in syphilis. Proc. N. Y. Path. Soc., *5*, 105.

1906

The pathological anatomy of the thyroid gland in Graves' disease. Proc. N. Y. Path. Soc., n.s., *6*, 71.
Exophthalmic goitre from the standpoint of serum therapy. N. Y. Med. J., *84*, 1061.
(With S. P. Beebe) A study of the biology of tumor cells. Brit. Med. J., *2*, 1559.
A histological study of the thyroid in 40 cases of Graves' disease. Trans. Assn. Am. Physn., *21*, 567.
(With C. G. L. Wolf) The clinical significance of the urinary nitrogen. Am. J. Med. Sci., *131*, 751.

1906-1907

(With S. P. Beebe) A study of the so-called infectious lymphosarcoma of dogs. J. Med. Res. *15*, 209.

A case of primary carcinoma of the liver. Proc. N. Y. Path. Soc., n.s., *6*, 168.

1907

(With C. G. L. Wolf) The clinical significance of the urinary nitrogen. —II. The metabolism in the toxemia of pregnancy. Am. J. Obst., *55*, 289.
Hemolysis in eclampsia. Science, *26*, 408.
Nitrogenous metabolism in typhoid fever. Med. Rec., *71*, 537.
The morphologic diagnosis of pathogenic protozoa. N. Y. Med. J., *85*, 1009.
Recent studies of syphilis. N. Y. State J. Med., *7*, 177.

1907-1908

Note on involution forms of spirochaete pallida in gummata. Proc. N. Y. Path. Soc., n.s., *7*, 166.

1908

Chorio-epithelioma. Am. J. Obst., *57*, 418.
Myxoma and diffuse hyperplasia of a full-term placenta. Proc. N. Y. Path. Soc., n.s., *8*, 84.
An intra-uterine perithelioma. Proc. N. Y. Path. Soc., n.s., *8*, 85.
Cancer problems. Harvey Lecture. Arch. Int. Med., *1*, 175; Harvey Lectures, 1907–1908, p. 34 (1909).
A classification of acidoses. Trans. Assn. Am. Physn., *23*, 31.
Acidosis and associated conditions. Arch. Int. Med., *2*, 330, 448.

1909

(With C. G. L. Wolf) The clinical significance of the urinary nitrogen.—III. Nitrogenous metabolism in typhoid fever. Arch. Int. Med., *4*, 330.
The epithelial cell changes in measles. J. Infect. Dis., *6*, 1.
Teratoma testis. Proc. N. Y. Path. Soc., n.s., *9*, 83.

1910

Animal experimentation and cancer. J. Am. Med. Assn., *54*, 267.
Chorioma: a clinical and pathological study. Surg., Gynec. Obst., *10*, 366.
The pathogenesis of the toxemia of pregnancy. Am. J. Med. Sci., *139*, 828.
The pathogenesis of the toxemia of pregnancy. *Part of:* Symposium on the toxemias of pregnancy, etc. Proc. Path. Soc. Phila., *13*, 65.
A case of Delhi boil. Proc. N. Y. Path. Soc., n.s., *10*, 12.
A case of chronic or unresolved pneumonia, polyserositis and senile malnutrition. Proc. N. Y. Path. Soc., n.s., *10*, 90.

1911

(With W. B. Coley) Acute lymphatic tuberculosis with purpura hemorrhagica. Trans. Assn. Am. Physn., *26*, 178.
The public and the medical profession. Med. Rec., *80*, 1209.
Teratoma testis and its derivatives. Surg., Gynec. Obst., *12*, 230.
Primary thrombosis of superior mesenteric vein. Proc. N. Y. Path. Soc., n.s., *11*, 106.

1912

The treatment of cancer on biological principles. N. Y. Med. J., *96*, 773.

1913

Endothelioma of lymph nodes. J. Med. Res., *28*, 1.
The cancer research hospital. N. Y. Med. J., *98*, 1241.
Extra testicular teratoma testis. Proc. N. Y. Path. Soc., n.s., *13*, 26.
Teratoma testis: chorioma of liver and lungs. Tridermal metastases in lymph nodes. Proc. N. Y. Path. Soc., n.s., *13*, 28.

1914

Precancerous diseases and precancerous lesions, especially in the breast. Med. Rec., *86*, 951.

1915

The hospital intern year as a requirement for medical lecensure. J. Am. Med. Assn., *65*, 670.
The incision of tumors for diagnosis. N. Y. Med. J., *102*, 10.

1916

(With L. D. Bristol et al.) Free tumor diagnosis as a function of state public health laboratories. Am. Soc. Cont. Cancer.
The thymus and its tumors; report of three cases of thymoma. Surg., Gynec. Obst., *22*, 461.
Principles and experiments in medical education. J. Am. Med. Assn., *66*, 635.
Pathological aspects of some problems of experimental cancer research. J. Cancer Res., *1*, 71.

1917

Radium therapy in cancer. J. Am. Med. Assn., *68*, 1238.
The influence of war on medical science. J. Am. Med. Assn., *69*, 249.
Incising tumors for diagnostic purposes. Med. Rec., *91*, 376.

1918

The relation of gastric ulcer to cancer. Ann. Surg., *67*, 715.
Miliary aspects of status lymphaticus. J. Am. Med. Assn., *71*, 1525.
Some factors influencing results of radium therapy. Radium, *11*, 73.
Influence of radium on cancer tissues. Am. J. Roent., *5*, 413.

1919

The place of pathological anatomy in military medicine. Mil. Surg., *44*, 273.
Pulmonary lesions of influenza pneumonia and a method of museum preparation. Proc. N. Y. Path. Soc., n.s., *19*, 15.
Some late and distant effects of radium. J. Cancer Res., *4*, 45.
A case of thymoma. Proc. N. Y. Path. Soc., n.s., *19*, 156.
(With R. B. Greenough and J. M. Wainright) What we know about cancer. Chicago, Am. Med. Assn. A handbook for the medical profession.
Neoplastic diseases (W. B. Saunders and Co., Phila. Ed. 1, 1919; ed. 2, 1922; ed. 3, 1928).

1920

The aims and methods of cancer diagnosis. Med. Rec., *98,* 200.

Report on the teaching of pathology. Proc. Assn. Am. Med. Coll., *18,* 136.

1921

The structure of nerve tissue tumors with reference to radium therapy. J. Nerv. Ment. Dis., *53,* 130; N. Y. Med. J., *113,* 420.

Tumors of nerve tissue in relation to treatment by radiation. Am. J. Roent., *8,* 497.

Der Einfluss Virchow's auf die medizinische Wissenschaft in Amerika. Virchow's Arch., *235,* 444.

Diffuse endothelioma of bone. Proc. N. Y. Path. Soc., n.s., *21,* 17.

1922

A review and classification of bone sarcomas. Arch. Surg., *4,* 485.

Experiences in the collection of museum material from army camp hospitals. Bull. Internatl. Assn. Med. Mus., *8,* 27.

The life and work of Dr. Lewis A. Stimson. Address delivered on Mrs. Dora Wheeler Keith's presentation to Cornell University of her portrait of Dr. Stimson, in Stimson Hall, January 9, 1922.

An analysis of radiation therapy in cancer. The Mutter Lecture, Trans. Coll. Physn. Phila., 3s., *44,* 190.

The mode of action of radiation upon carcinoma. Am. J. Roent., *9,* 331.

Preventable cancer. Health News, Mo. Bull. N. Y. State Dept. Health, n.s., *17,* 244.

1923

"Identity," *in* second ed. Legal Medicine and Toxicology (Ed. by Peterson, Haines and Webster) (W. B. Saunders and Co., Phila.) *1,* 132. "The signs of death," ibid., p. 175. "Sudden death," ibid., p. 209.

(With W. S. Stone) An unusual alteration in the natural history of a giant-cell tumor of bone. Arch. Surg., *7,* 280.

1924

Influence of radiation therapy on the study of cancer. Canad. Pract., *49,* 95.

Further report on endothelial myeloma of bone. Proc. N. Y. Path. Soc., n.s., *24,* 93.

Is radiation an epoch in cancer therapy? Canad. Pract., *29,* 414.

1925

Rational pathology and the new therapeutics. Practical Lectures, 1923-24 series, p. 116.

The diagnosis of cancer. J. Am. Med. Assn., *84,* 1.

Some consideration on the etiology of cancer. Canad. J. Med. Surg., *57,* 117; Canad. Lancet Pract., *64,* 217.

Twenty years' progress in American teaching of pathology. Proc. Ann. Cong. Med. Ed., p. 21.

1925-1926

The chances of death from carcinoma. Assn. Life Insurance Med. Directors of America, Abstr. of Proc., *13*, 50.

1926

The relation of trauma to malignant tumors. Am. J. Surg., *40*, 30.
Tissue reactions to radiation. Caldwell Lecture, Am. J. Roent., *15*, 93.
Radiation osteitis. Acta Radiologica, Stockholm, *6*, 399.

1927

Prevention of Cancer. Cancer Control, p. 165; Suppl. to Surg., Gynec. Obst., *44* (May).
Some phases of intraoral tumors, with special reference to treatment by radiation. Radiology, *9*, 359.
Memorial Hospital. N. Y. State J. Med., *27*, 1004.

1928

The classification and treatment of bone sarcoma. Report Internatl. Conference on Cancer (third), London, p. 365.
The causal and formal genesis of cancer. Report Internatl. Conference on Cancer (third), London, p. 1.
(With A. R. Stevens) Adenocarcinoma of the testis in the adult. Ann. Surg., *88*, 1074.

1929

Lympho-epithelioma. Am. J. Path., *5*, 99.
The relation of cancer to old age. Am. J. Med. Sci., *177*, 461.
Radiosensitive epidermoid carcinomas. Am. J. Roent., *21*, 313.
Cancer as a public health problem. Pub. Health Rep., U.S.P.H.S., *44*, 2093 (1929); Med. Officer, *42*, 205.
Radiosensitivity. Radiology, *13*, 313.
(With R. B. Greenough and J. C. A. Gerster) The medical service available for cancer patients in the United States. J. Am. Med. Assn., *93*, 165.
Special aspects of neoplasms in aged. Bull. N. Y. Acad. Med., n.s., *5*, 104.
The causes and diagnosis of intraoral carcinoma. Prepared for and published in cooperation with the Am. Soc. for Cancer Control, Chicago Dent. Soc. Official Bull., *9*, 6.

1930

Factors determining radioresistance in tumors. Radiology, *14*, 186.
Some types of radioresistant tumors with results of treatment. Am. J. Surg., n.s., *8*, 142.
Problems of melanoma. Brit. Med. J., *2*, 852.

1932

The university and the medical profession. Bull. N. Y. Acad. Med., *8*, 1.

1934

Early experiences in radiation therapy. Janeway Memorial Lecture, delivered before the American Radium Society during the American

Congress of Radiology, Chicago, Ill., Sept. 25-30, 1933. Am. J. Roent., *31*, 153.

Cancer. Citizens' Aid Society Memorial Address, presented at the annual meeting of the Minnesota State Medical Association, Rochester, May 24, 1933. Minnesota Med., *17*, 53.

1935

Some results of modern clinical cancer research. Read before the Cincinnati Academy of Medicine and First Counsellor District of the Ohio State Medical Association and the Cancer Council, Nov. 12, 1934. J. Med., *16*, 15.

General significance of bacterial infection in cancer. Libro de Oro dedicado al Prof. Dr. Angel H. Roffo (A. Guidi Buffarini, Buenos Aires) p. 375.

Modern attitude toward traumatic cancer. Arch. Path., *19*, 690.

The general pathological conception of cancer. Canad. Med. Assn. J., *33*, 125.

Fascial sarcoma and intermuscular myxoliposarcoma. Arch. Surg., *31*, 507.

1936

Problems in histological tumor diagnosis. Reports II. Internatl. Cong. Scient. and Soc. Campaign against Cancer, *1*, 215.

1937

The development of laboratory service in a cancer hospital. Ann. Surg., *106*, 715.

1938

Adaptation as a factor in the cure of cancer by radiation. Am. J. Roent., *39*, 165.

The public and the cancer problem. Science, n.s., *87*, 399.

1939

General pathology of lymphosarcoma. Bull. N. Y. Acad. Med., *15*, 92.

1940

Etiological indications of early gastric cancer. Rev. Gastroenterol., *7*, 305.

A survey of cancer in childhood. Cancer in childhood (C. V. Mosby Co., St. Louis, 1940) p. 13.

William Bowie

WILLIAM BOWIE

1872–1940

BY J. A. FLEMING

William Bowie was born May 6, 1872, at Grassland, an estate near Annapolis Junction, Anne Arundel County, Maryland. He died August 28, 1940, at Mt. Alto Hospital in Washington, D. C., after an illness of about three weeks. Funeral services were held at St. Thomas Episcopal Church, Washington, D. C., August 30, 1940, followed by burial in Arlington National Cemetery.

His family, descended from a long line of English ancestors, many of whom were knighted, was traced back as far as 1325. His American forebears, all of whom played important parts in the history of Maryland, originated with John Bowie, Sr. (1688-1759), who emigrated from England to America about 1705-06. William Bowie's great grandfather Thomas Bowie (1767-1823) was Colonel of the 34th Regiment of the Maryland forces in the war of 1812, and his father Thomas John Bowie (1837-1898) served as Deputy Provost Marshal for Prince Georges County, Maryland, during the Civil War and was later elected for one term in the House of the Maryland Legislature. William Bowie's mother, Susanna Anderson (Bowie), whose English ancestors have been traced from early in the Fourteenth Century, was also descended from a well-known Maryland family, the activities of many of whom helped make history in Maryland. On June 28; 1899, William Bowie married Elizabeth Taylor Wattles of Alexandria, Virginia, who survives him and who is also of illustrious English and American ancestry. There were two children, William (deceased in infancy) and Clagett, an aeronautical engineer and designer, presently of Baltimore, Maryland. Bowie was also survived by two brothers: Edward Bowie, an eminent meteorologist, who has since died, and John Bowie, who resides at Grassland, the old family estate.

William Bowie received his early education in the public schools and at the venerable St. John's College of Annapolis, Maryland. He later attended and received degrees from Trinity College, Hartford, Connecticut (B.S. 1893; M.A. 1907; Sc.D. 1919) and Lehigh University (C.E. 1895; Sc.D. 1922). He also received honorary degrees (LL.D. 1936) from the University of Edinburgh, Scotland, on the occasion of the meeting of the International Union of Geodesy and Geophysics of which he was President, and from the George Washington University (Sc.D. 1937).

He entered the service of the United States Coast and Geodetic Survey on July 1, 1895, first as a junior officer in the field and later as chief of parties engaged in triangulation and base-line measurements in many states of the Union as well as in the Philippines, Puerto Rico, and Alaska. He was appointed in 1909 as Inspector of Geodetic Work and Chief of the Computing Section, which was re-designated as the Division of Geodesy from October 15, 1915. He rendered distinguished service in this position until he was retired in May, 1936, having reached the age of 64, the retiring age for commissioned officers of the Survey, but he was recalled to active duty on June 1, 1936, and served until his final retirement on December 31, 1936.

During his connection of over 40 years with the Survey he won distinction both at home and abroad for his notable attainments in geodesy, related science, and engineering. Aside from directing the main function of the Computing Section and the Division of Geodesy, namely, extending control surveys consisting of triangulation, leveling, and pendulum and gravity work, throughout the country, he found time to make researches in earth-physics which were the basis of many official publications and his well-known book "Isotasy." In addition he publicized the general usefulness and public value of surveying and mapping by contributing hundreds of articles to current journals and newspapers. During World War I, he was commissioned a major in the Corps of Engineers, U. S. Army, and was assigned to the Mapping Division of the Office of the Chief of Engineers in Washington (August, 1918, to February, 1919).

Dr. Bowie's scientific activity was directed chiefly toward the accomplishment of three general objectives: (1) Promotion of mapping of the United States and its territories and improvement of cartographic methods and technique. (2) Expansion of geodetic work and improvement of instruments and methods. (3) Promotion of interest and progress in geophysical sciences, particularly through the media of national and international bodies.

(1) Promotion of Cartography and of Improved Instruments and Technique

Earnest advocacy of more and better maps was an outstanding feature of Bowie's scientific career. Although from a professional standpoint his chief interest was in the somewhat limited field of geodesy, he always viewed his work from the broad concept of its value and general utility as a part of mapping which then sorely needed a champion. On this point he brought to bear all his energy and eloquence, never letting pass an opportunity to impress its importance upon his countrymen. To this end he addressed many scientific and engineering societies and contributed articles to newspapers and technical journals, always stressing the need for, and the great advantage to be derived from, adequate surveys and maps of the United States and its outlying territories. For this alone his contribution to posterity merits first consideration, notwithstanding his geodetic research for which he received nearly all his honors. He was always ready to support his assertions by citing instances of losses resulting from the destruction of highway structures because of lack of proper planning where highways had to be extended over unmapped areas. Another of his theses was the dependence on mapping in evaluating available water supplies and in the solution of certain biological problems. From the economic viewpoint he emphasized the fact that good maps and good control-surveys make possible the execution of our various enterprises in a more efficient way, thereby reducing the cost to our people of private and public works.

Of great practical advantage to geodetic operations was Bowie's initiation of a movement to place surveying and mapping in North America on a single geodetic datum known as the

North American Datum,[1] which was adopted by Canada and Mexico in 1913. By this the execution of surveys along their common borders in a uniform and systematic manner was assured and a mutual understanding in geodetic matters established.

The deplorable lack of co-ordination, uniformity, and standardization of methods in the various Governmental organizations engaged in this work could not long escape notice by one as assiduous as Bowie in the cause of maps and mapping. Working through the National Research Council, he pointed out the unsatisfactory and wasteful duplication of the work. He advocated, as the best means for correcting this condition, the establishment of an agency within the Government to study the problem and undertake the task of co-ordinating the services involved. The result of his campaign was the creation in 1919 of a Board of Surveys and Maps, later known as the Federal Board of Surveys and Maps. He was chairman of this Board during its early years. This Board rendered useful service to units engaged in mapping. Its functions were transferred to the Bureau of the Budget in 1942.

Under Bowie's supervision from October 10, 1909, there were added many thousand miles of arcs to the triangulation-net of the country. To make an equitable distribution of the closing errors among the arcs, which, using the old system, would have been impracticable, Bowie suggested the establishment of juncture figures and the adjustment of intervening arcs as separate sections. This simplified method was first successfully applied to the first-order control-arcs in the western part of the United States and later to the eastern half.

Bowie was also largely responsible for the organization in the American Society of Civil Engineers of a Division of Surveying and Mapping, of which he was Chairman until 1940. From the work of this Division has come a better appreciation of the economic advantages of good maps and the realization of their almost universal application to problems of the national services.

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[1] "For all connected triangulation in the United States, Canada, and Mexico, the initial point is the Triangulation Station, Meades Ranch, in the State of Kansas. Its adopted latitude and longitude and the azimuth from it to the Station Waldo are called the North American Datum." [W. Bowie, Jour. Frank. Inst., p. 665, June 1914.]

(2) Expansion of Geodetic Work and Improvement of Instruments and Methods

Bowie was placed in charge of the geodetic work of the Survey on October 10, 1909. At that time 10,000 miles of triangulation and 30,000 miles of leveling had been done. During the 27 years of his administration, these figures were raised to 68,000 and 261,000 miles, respectively. At the same time the number of gravity stations was increased from 60 to 720 and astronomical Laplace stations from about 32 to 390.

It was during this period that great changes in the tempo of field work of the Survey took place. During the early years of the present century, the field-equipment was transported from station to station by mules and horses, and the necessity of erecting wooden towers rendered progress comparatively slow. With the advent of the rapid autotruck with all modern conveniences and portable steel towers which could be quickly erected and dismounted, the geodetic field work was greatly improved and its progress accelerated. Bowie quickly envisioned the advantages of these innovations and adopted them in the field work of the Survey.

One of the problems which confronted Bowie pertained to the procurement of suitable instruments and the reconditioning of old ones which through usage had become incapable of yielding results of the accuracy required for first-order triangulation. One of the various improvements advocated by Bowie, after careful investigation, was the substitution of silver circles on the theodolites. This change was suggested for the purpose of eliminating any inaccuracy which might result from the displacement of the silver inlay originally set in the bronze circles of these instruments. These silver circles were found to be an important improvement and were gradually adopted for the theodolites of the Survey.

Bowie also improvised in the field a base tape-stretcher apparatus which was later improved and manufactured in the Survey's instrument-shop.

He was also responsible for improvements in gravity instruments and methods. At his suggestion observations were made in 1914 which showed the possibility of using the noon signals transmitted by the United States Naval Observatory over the wires of the Western Union Telegraph Company, in the determination of the periods of the pendulums in gravity work. Bowie had had much experience in time determinations for longitude work in which the program of observations at each station included an exchange of telegraphic signals with an existing station for the purpose of eliminating certain errors. He visualized the use of the daily Western Union signals for pendulum gravity determinations where, as was usually the case, a pendulum gravity station was in reasonable proximity to the telegraph office. The trial of the method in 1914 proved feasible and it was used thereafter until the development of new equipment. This so accelerated gravity observations that a single station could be completed on the average in about one week whereas before that time an average of about three weeks was required at each station. Furthermore, only one observer was required by the new method instead of two.

The subject of isostasy has been under investigation at the United States Coast and Geodetic Survey for many years. The first work there was done under the direction of Professor J. F. Hayford, Bowie's predecessor in geodetic operations, in connection with the deflection of the vertical and the determination of the size and shape of the earth. This work was later extended to include investigations of the effect of topography and isostatic compensation upon the intensity of gravity. These investigations of gravity and isostasy were continued under Bowie from 1909 and the results obtained were set forth in a number of publications of the Survey. It was found that the theory of isostasy was useful in accounting for abnormal values of gravity and for studying underground structure. Isostatic anomalies were shown to indicate a departure from normal conditions of specific gravity of the rock underlying the point of observation.

Bowie's investigations of gravity paved the way for the use of determinations of gravity in studying geological structure and the gravity method which has proved so valuable in geophysical exploration.

During the gravimetric survey of Holland, 1912-1922, the swampy nature of certain parts of that country made it impossible to find any fixed base for the pendulum apparatus. Measures had to be taken, therefore, for ensuring the accuracy of the observations in spite of the unsteadiness of the instrument. A method was accordingly developed by Dr. F. A. Vening Meinesz of swinging two pendulums simultaneously in the same swinging plane, thereby eliminating the effect of the horizontal accelerations. The success of this method when applied to the unstable terrain of Holland led to the idea that it could also be applied to ships at sea; experiments performed on board submarines while submerged demonstrated the feasibility of this method for making gravity determinations over ocean areas.

Bowie was greatly interested in this improved method in determination of gravity and warmly encouraged Vening Meinesz in pursuing his observations at sea. He took a leading part in arranging collaboration of Vening Meinesz and the Dutch authorities with the United States Navy and other American organizations so that values of gravity at sea might be obtained by the United States and other interested governments or organizations. Largely as a result of his efforts, three expeditions were successfully concluded in 1928, 1932, and 1936-37, chiefly in the vicinity of the West Indies. The results of these expeditions confirmed the theories of Airy[2] and Pratt[3] that the earth's crust under the oceans is in isostatic equilibrium with the crust in the continent—an idea which was ardently supported by Bowie. They also yielded vital supplemental data which permitted the interpretation of the geology and geophysics of the region surveyed.

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[2] G. B. Airy, On the Computation of the effect of the attraction of mountain masses as disturbing the astronomical latitude stations in geodetic surveys. Phil. Trans. Roy. Soc. London, vol. 145, pp. 101-104 (1855).

[3] J. H. Pratt, On the attraction of the Himalaya Mountains and of the elevated regions beyond them upon the plumb line in India. Phil. Trans. Roy. Soc. London, vol. 145, pp. 53-100 (1855).

(3) *National and International Activities*

Few Americans have wielded so great an influence in national and international scientific bodies concerned with geodesy and geophysics as William Bowie. He was present as the United States representative at the last General Assembly of the International Geodetic Association at Hamburg in 1912, when the Fiftieth Anniversary of that organization was celebrated. At the triennial conventions of that Association representative geodesists from the twenty or more adhering countries were brought together and their personal contacts and discussions resulted in the greatest benefit to the science of geodesy throughout the world.

With the outbreak of World War I, the activities of many international scientific organizations were either suspended or terminated, but the work of the International Geodetic Association was continued on a limited scale by the so-called Reduced Geodetic Association to which seven neutral countries, including the United States, belonged. After the United States entered the war in 1917, the work was carried on by the other six member-nations, to which too much credit cannot be given for preventing a break in international co-operation in geodetic matters during World War I.

Contrary to expectations, the old International Geodetic Association was not revived with the return of peace. At a meeting held in Brussels in 1919, at which Bowie was one of the leading delegates from the United States, the International Union of Geodesy and Geophysics was created and its Section (later designated Association) of Geodesy was destined to replace the old International Geodetic Association. At the first plenary meeting of the Section at Rome in 1922, all of the countries forming the Reduced Geodetic Association were represented.

Dr. Bowie was President of the Section of Geodesy from its establishment in 1919 until 1933. One of the troublesome questions which soon claimed the attention of the International Union was the admission of the Central Powers and their allies to membership. Although several of the European delegates were, from the first, bitterly opposed to their admission, Bowie consistently denounced this limitation to the international character of the Union and, in his capacity as ex-officio Vice-President of the Union, threw his influence always on the side of tolerance and international understanding. In 1926, the statutes of the Union were revised and the clauses to which the Central Powers took umbrage were eliminated.

In all the deliberations of the Union as well as those of the Section (later Association) of Geodesy, the words of Bowie always carried weight. His dignified bearing and commanding presence assured him the respect of all and his clever diplomacy often succeeded in bringing about satisfactory settlements of questions where prolonged and heated discussion would have produced at best a doubtful solution. He was a past master of the art of conducting a meeting and under his general guidance even much-contested matters were often dispatched with surprising smoothness. He was strongly in favor of working through committees as the best manner of dealing with disputed questions, since spontaneous debate in international assemblies, where different languages are involved, often becomes interminable.

In token of his unusual ability in parliamentary practice, coupled with his high scientific attainments, he was elected President of the International Union of Geodesy and Geophysics from 1933 to 1936. In 1936 he received the degree of Doctor of Laws from the University of Edinburgh. Because of his intimate acquaintaince with the affairs of the Union, he was called upon to act as Secretary, in the absence of Brigadier Winterbotham, at the General Assembly of the Union held in Washington in 1939.

Bowie was instrumental in bringing about the adoption of the "Hayford Spheroid," known as the "international spheroid," at the meeting of the International Union of Geodesy and Geophysics at Madrid in 1924.

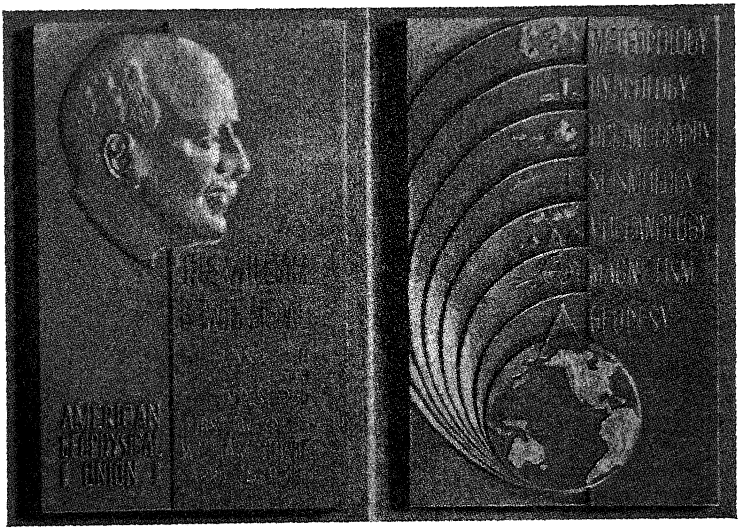
In the minutes of the Executive Committee of the American Geophysical Union one meets with Bowie's name at every turn because of the prominent part he took in shaping the destiny of the Union and in directing its policies. He was the first Chairman of its Section of Geodesy, holding that post from 1919 to 1922. He was General Secretary of the Union from 1929-1932.

His counsel, wise judgment, and enthusiasm had much to do with the development of the Union (which originally had a membership of only 50 and whose membership at the time of Bowie's death was over 1400, and in 1949 is over 4500) and with the encouragement of geophysics as a profession throughout the United States. That the Union was not unmindful of his outstanding service was attested by the establishment of the William Bowie Medal, endowed by friends and co-workers, for award for distinguished attainment and outstanding contribution to the advancement of co-operative research in fundamental geophysics.

The following extract from the citation (April 28, 1939) when the first award of this Medal was made to Bowie, epitomizes the regard in which he was held by his colleagues.

> "It is particularly fitting that the first award of this Medal should be to the man whose name the Medal bears. It is not necessary here, among your intimate friends and colleagues in geophysics, to refer specifically to your long list of scientific accomplishments and honors. But we do feel that in presenting you with the first imprint of this Medal that has been created in your name and that of the organization for which you have worked so long and so lovingly, we are not handing you merely a bit of stamped and engraved metal, but rather a powerful talisman of those human forces, affection, esteem, and tradition so fundamental to your spirit of progress. It is sincerely hoped that in the years to come this Medal, through its future awards, will continue to promote and to recognize that spirit of helpfulness and friendliness in unselfish co-operative research which you have so bountifully displayed."

In all deliberations he stood for encouragement of scientific effort and co-operation with agencies which would advance the cause of geophysics. As a member of the National Academy of Sciences since 1927 he was affiliated with the Section on Astronomy. He did much to interest the Academy in geophysics and was one of those who took an active part in the organization and endowment of the Woods Hole Oceanographic Institution. He was a firm advocate of enlarging the scope and membership of the American Geophysical Union, preferring that it should take the form of an association or society rather than that of a committee. He usually held definite opinions on the various subjects that came up for discussion and by virtue of his oratorical ability and the felicitous expressions always at his command often carried his point in spite of opposition.



WILLIAM BOWIE MEDAL OF THE AMERICAN GEOPHYSICAL UNION

(PHOTOGRAPH OF REVERSE AND OBVERSE OF MEDAL AS FIRST AWARDED WILLIAM BOWIE.)

The secret of Bowie's great productivity was in the sharp differentiation he made between hours for work and for mental and bodily recreation. In a letter to Professor William H. Burger of Northwestern University on May 31, 1935 he wrote:

> "I have schooled myself to leave my work at the office and therefore during the evening I can read, talk, listen to the radio, play a game of contract, or do other things without my mind being in a whirl concerning office matters. I believe that any one who has a big job must have freedom from it

for some of the day. I try to drive as hard as I can while I am at the office, but at the close of the official day I am through until the next morning. Under this plan I seem to be standing up in fine shape, as I have written you before."

(4) Leadership

Bowie's scientific ability was enhanced by his rare quality of leadership—one possessed by so few scientists. It has fallen to the lot of few American men of science to be endowed with the high qualities of leadership and organization which characterized Bowie throughout his long career in government service. His unswerving purpose was to build up a unified and contented group of efficient workers as the best way to advance the work in view. He had the rare faculty of effecting the accomplishment of his objectives through the co-operative efforts of the men under his direction, a large part of which was due to his honesty and generosity of bestowing credit where it was due—he thus assured zealous and loyal co-operation in the work.

His popularity as a leader was evidenced on many occasions but perhaps never to better advantage than at the time of his retirement from active service when his Division held a dinner and exercises in his honor. He was outstandingly successful as a chief of division and set an example of administration which others in like positions would do well to emulate.

Dr. Bowie took much interest in educational matters and held very sane views regarding public instruction, insisting that the object of study was to understand the subject and not to over-strive to obtain good marks.

Some of his cogent ideas on the subject are illustrated in the following extracts from letters to Professor Burger:

"I am inclined to think that your success with the Coast Survey and since may be due to the fact that you took a general science course rather than an engineering one. Hayford was quite convinced that the strictly engineering courses did not give a man a well-rounded education. I am becoming more convinced than ever that we should have in an engineering course more physics, mechanics, mathematics, English, history, and perhaps philosophy and economics. They are the things that enable one to understand life. Learning how to build bridges and highways, etc., makes men too narrow unless they have these other things. When Hayford went to Northwestern he started the five-year course in order that the students would have some cultural courses. In this he was sound.

"These fundamental things that I have mentioned above are the basis of all engineering. A man well grounded in these fundamentals can soon learn the technical phases of any engineering job to which he may be called. I find in the Division of Geodesy that our field men who have had special courses in physics while in their Colleges and Universities are able to handle our work a little better than those who took merely structural and construction courses." (June 13, 1935.)

"I think there is too much attention paid by students at high schools and universities to marks. They think if they get a good mark they are doing good work. As a matter of fact the mark may be due merely to cramming for the recitation or the quiz without any real intention of understanding what the subject is all about.

"I am inclined to favor the system used at the Harvard Law School. They do have recitations in a sense. The students are required to get up and talk about certain cases and naturally they do not like to make a mess of it. But no marks are given or taken into consideration during the entire year. At the end of the year a comprehensive examination is given in each subject taken. The examination questions are designed to show whether a student really understands his subject and the fundamental principles of law. There are scarcely any questions involving merely memory tests. This it seems to me is the ideal way of conducting any course. Then the student tries to learn something about it rather than to get by in daily recitations and occasional quizzes.

"I believe outside activities of the school and college, if not overdone, are a great benefit to the student. After all when we get through college our dealings are principally with people and not with things. Of course we must know fundamental principles of science or anything else that we study, but dealing with people is very important. If one goes through college without contacting other students in extra-curricular activities, he is very much handicapped when he gets out into the world's work. I find that men who have had such extra-curricular work in college make better chiefs of parties. They know how to handle men, to pep up their morale, and to make them enjoy a rough and tumble life." (December 27, 1935.)

Despite his official responsibilities Bowie found time to do some teaching outside of the Coast and Geodetic Survey. From

1912 to 1917 he conducted a short course in geodetic surveying and practical astronomy at Columbia University summer surveying camp near Litchfield, Connecticut. He was also special lecturer at Lehigh University from 1924 to 1936. He never lost an opportunity to urge young men to make the most of the best in them and to encourage them to strive for leadership in their chosen work.

He was also an excellent public speaker and brilliant conversationalist, being never at a loss for something to say and how to say it. He was much given to citing telling examples to reinforce his statements. In an address given before the South Carolina Society of Engineers, in emphasizing the inadequacy of some descriptions of land-marks, in connection with his campaign for better maps, he cited an old deed which read "Beginning at a point on Powdermill Hill where Bill Jones killed the Indian." Another instance of his shrewd humor may be noted in a conversation with one of his friends when he said by way of precept: "If you want to make a name for yourself in science, choose for investigation some subject which nobody knows anything about and which, moreover, nobody cares anything about, such as isostasy. Then you will receive bouquets instead of bricks!"

(5) Affiliation with Scientific Bodies, Honors, and Awards

Scientific bodies—Bowie was interested in many scientific societies and organizations, to which he contributed much of his time, both as an active and as an honorary member. Among them may be mentioned the following:

National Academy of Sciences
National Research Council in its Division of Foreign Relations
Academy of Sciences of the Institute of France
Academy of Sciences of Norway
National Academy of History and Geography of Mexico
Russian Geographical Society
Finnish Geographical Society (Honorary membership had been unanimously voted but Bowie's death occurred before its finalization)

International Union of Geodesy and Geophysics (President, 1933-36)
International Association of Geodesy (President, 1919-33)
Federal Board of Surveys and Maps (Chairman, 1922-24, member of Executive Committee, 1920-36)
American Society of Civil Engineers (Chairman of Division of Surveying and Mapping from its organization in 1926)
American Institute of Consulting Engineers
American Geographical Society
American Association of Geographers
American Astronomical Society
American Engineering Council (Committee on Surveying and Mapping)
American Society of Photogrammetry
American Geophysical Union (President, 1919-22 and 1929-32)
American Association for the Advancement of Science
Pan American Institute of Geography and History (Honorary President from 1929)
Society of American Military Engineers (President, 1938, and Executive Officer and Editor of *The Military Engineer* from January 1-August 28, 1940)
Geological Society of America
Geological Society of Washington
National Geographic Society
Philosophical Society of Washington (President, 1926)
Seismological Society of America
South Carolina Society of Civil Engineers
Washington Academy of Science (President, 1930)
Washington Society of Engineers (President, 1914)

He was a member of the following Greek-letter fraternities:
Delta Kappa Epsilon
Phi Beta Kappa
Sigma Xi (President, District of Columbia Chapter, 1935-36)

He enjoyed memberships in the following clubs:
Cosmos Club of Washington (life member)
Army and Navy Club of Washington

Honorary awards and medals—Recognition of Bowie's scientific activities, other than awards of honorary degrees, may be noted as follows:

The Charles Lagrange Prize by the Royal Academy of Belgium in 1932

The Elliott-Cresson Medal by the Franklin Institute of Philadelphia in 1937 for contributions to the science of geodesy

Medal and Diploma as an Officer of Orange-Nassau by the Queen of The Netherlands in 1937 [The Medal and Diploma of the Order were presented through the Minister of The Netherlands at Washington with the following citation: "In recognition of outstanding achievements in the interests of international science and geodesy and his collaboration with Dr. F. A. Vening Meinesz, Professor of Geodesy at the University of Utrecht, The Netherlands, and a Member of The Netherlands Geodetic Commission, in the determination of gravity at sea."]

Decoration of the Cross of Grand Officer of the Order of St. Sava from Yugoslavia in 1939

First award of the William Bowie Medal by the American Geophysical Union in 1939

Sometimes the development of regard of scholars in other fields is reflected in doggerel rhymes so often used in friendly get-together meetings. Thus as regards Bowie's work in isostasy in the earlier days, about a quarter-century ago, before the geologist had altogether accepted isostasy, at a meeting of the Geological Society of Washington during December, 1923, Henry G. Ferguson and Frank C. Calkins submitted the following verses, which were sung to the tune of "Maryland, My Maryland" by the chorus of the Pick and Hammer Club:

What is it rules the upper crust?
  Isostasy! Isostasy!
What actuates the overthrust?
  Isostasy! Isostasy!
What gives the shore-line wanderlust?
What humbles highlands in the dust?
What makes the strongest stratum bust?
  Isostasy! Isostasy!

That all's in equilibrium,
 So Bowie says, so Bowie says,
Is proven by the pendulum,
 So Bowie says, so Bowie says,
And why the plumb line's never plumb,
And why the mountains go and come,
Is simple as the rule of thumb,
 So Bowie says, so Bowie says.

In vain conservatives have cussed
 Isostasy! Isostasy!
The strongest power on earth is just
 Isostasy! Isostasy!
So we must down our deep disgust;
If we'd be up-to-date, we must
Roll up our eyes and take on trust
 Isostasy! Isostasy!

It is recalled that on the occasion of a farewell party to Bowie by members of his staff and friends at the United States Coast and Geodetic Survey, the above verses were sung by all in attendance greatly to Bowie's delight, as indeed must have been the case when they were presented originally.

The appreciation of Bowie's personal qualities has been well stated by his friend Professor C. R. Longwell of the Department of Geology at Yale University in the following words:

> "Bowie will be long remembered as an outstanding personality. He was a man of striking appearance and with a remarkably genial disposition. In scientific discussions his ready wit and good-natured banter were perhaps as effective as the force of his arguments. Undoubtedly his genuine interest in people, young and old, his uniform cheerfulness and kindliness on all occasions, and his unusual ability in forceful and entertaining conversation were large assets in the successful performance of his administrative and scientific tasks. Certainly these qualities won him the admiration and affection of numerous people, representing various sciences and professions, who now blend with their tribute to his accomplishments sincere mourning at the loss of a friend."

Bowie's breadth of vision, his encouragement of younger men, his interest in other than his immediate field, his unselfish service in his every contact, and his unflagging zeal and devotion to bring together the seven main fields of geophysics as a real Union endear and perpetuate his memory, not only to his own countrymen but to all of those many colleagues in almost every country of the world who had the privilege of his acquaintance.

BIBLIOGRAPHY OF WILLIAM BOWIE

BY J. A. FLEMING AND H. D. HARRADON

It has been difficult to prepare a complete bibliography of publications and writings by Bowie. In the preparation of the following material the authors have had the generous assistance of Captain H. W. Hemple, presently Chief of the Division of Geodesy of the Coast and Geodetic Survey, of his assistants, and of the Librarian of the Survey. As will be noted, there are included, in addition to major scientific reports and addresses, numerous reviews, abstracts, and articles in newspapers; thus the increasing tempo of Bowie's activities, both as a scientist and as a public spirited citizen, is clearly indicated. Some of his publications doubtless have been omitted from this list, but such omissions are probably few in number.

Abbreviations used in references follow general conventions but in order to avoid any ambiguity, they are indicated in the key below:

Abbr'n.	*Meaning*	*Abbr'n.*	*Meaning*	*Abbr'n.*	*Meaning*
Abs.	Abstract	Frank.	Franklin	Phil.	Philosophical
	Abstracted	Gaz.	Gazette	Pop.	Popular
Adv.	Advancement	Geod.	Geodetic	Proc.	Proceedings
Aeron.	Aeronautical	Géod.	Géodésie	Pub.	Public
Amer.	America	Geog.	Geografía		Published
	American		Geographic	Pub'n.	Publication
Ann.	Annual	Geol.	Geological	Rep.	Reprint
App.	Appendix		Geologist		Reprinted
Ass'n.	Association		Geology	Res.	Research
Assoc.	Associated	Geophys.	Geophysics	Rev.	Review
Astro.	Astronomical	Géophys.	Géophysique		Reviewed
Astroph.	Astrophysical	ibid.	ibidem		Revista
Beitr.	Beiträge	Inst.	Institute	Sci.	Science(s)
Bol.	Boletin	Inst'n.	Institution	Scot.	Scottish
Bull.	Bulletin	Jour.	Journal	Sec.	Section
Bur.	Bureau	Mag.	Magazine	Ser.	Serial
Cal.	California	Mar.	Marine		Series
Chap.	Chapter	Mer.	Merchant	Serv.	Service
Circ.	Circular	Metal.	Metallurgical	Smith.	Smithsonian
Civ.	Civil	Mil.	Military	Soc.	Society
Conf.	Conference	mimeogr.	Mimeog'phed	Spec.	Special
Cong.	Congress	Mitteil.	Mitteilungen	Stand.	Standards
Conn.	Connecticut	Month.	Monthly	Supp.	Supplement
Conserv.	Conservation	Mss.	Manuscript	Surv.	Survey
Cont.	Contributions	Nation.	National	Tech.	Technical
C.-R.	Comptes Rendus		Nationale	Trans.	Transactions
Div.	Division	no.	number		Translation
Ed.	Edition	Obs.	Observatory	U. S.	United States
Eng.	Engineering	p.	page	vol.	volume
	Engineers	pp.	pages	Wash.	Washington, D. C.
Ext.	Extension	Petrol.	Petroleum	Zs.	Zeitschrift
ff.	following (pages)				
Jan.	January	———	May	Sep.	September
Feb.	February	———	June	Oct.	October
Mar.	March	———	July	Nov.	November
Apr.	April	Aug.	August	Dec.	December

Some recent triangulation in the southwest part of the United States (presented before Phil. Soc. Wash., Mar. 10, 1910).

Determination of the height and geographical position of Mt. McKinley. Bull. Amer. Geog. Soc., vol. 42, no. 4, pp. 260-261 (Apr., 1910).

Primary triangulation and base measurement by the Coast and Geodetic Survey (presented before Phil. Soc. Wash., in 1910).

The measurement of two primary base lines with invar tapes (presented before Phil. Soc. Wash., Jan. 28, 1911). Eng. News-Record, vol. 65, no. 11, p. 315 (Mar. 16, 1911).

The Texas-California arc of primary triangulation. Abs., Science, vol. 33, no. 849, pp. 838-839 (Apr. 7, 1911); also abs. Bull. Amer. Geog. Soc., vol. 43, no. 6, pp. 447-448 (June, 1911).

The completion of Texas-California arc of primary triangulation. Abs., Science, vol. 33, no. 854, pp. 748-750 (May 12, 1911); Amer. Geog. Soc., (June, 1911); Sci. Amer. Supp., vol. 74, p. 412 (Dec. 28, 1912). [Rev. by Dr. E. Hammer, Petermann's Mitteil., p. 209, Apr., 1913.]

Recent gravity-work by the Coast and Geodetic Survey (presented before Phil. Soc. Wash., May 6, 1911). Abs., Science, vol. 33, no. 858, pp. 911-912 (June 9, 1911).

Recent gravity work in the United States. Amer. Jour. Sci., vol. 32, pp. 101-113 (Aug., 1911).

Primary base lines at Stanton, Texas, and Deming, New Mexico. Ann. Rep. U. S. Coast Geod. Surv., 1910, App. 4, pp. 143-171, Gov. Printing Office, 1911.

Making practical use of the U. S. primary triangulation systems (presented before Amer. Ass'n. Adv. Sci., Sec. D, Wash., Dec. 28, 1911). Eng. News, vol. 67, no. 8, p. 341 (Feb. 22, 1912).

Some relations between gravity anomalies and the geologic formations in the United States. Amer. Jour. Sci., vol. 33, pp. 237-240 (Mar., 1912).

Some results of the Hayford method of gravity reductions. Jour. Wash. Acad. Sci., vol. 2, no. 21, pp. 499-504 (Dec. 19, 1912).

Effect of topography and isostatic compensation upon the intensity of gravity [with J. F. Hayford]. Spec. Pub'n. 10, U. S. Coast Geod. Surv., 132 pp., 1912.

Texas-California arc of primary triangulation. Spec. Pub'n. 11, U. S. Coast Geod. Surv., 141 pp., 1912. [Rev. in Bull. Amer. Geog. Soc., vol. 45, no. 1, p. 54 (Jan., 1913).]

Effect of topography and isostatic compensation upon the intensity of gravity. Spec. Pub'n. 12, U. S. Coast Geod. Surv., 28 pp. with 5 maps, 1912. [Rev. as "Gravity publications" by Dr. Kohlschütter, Petermann's Mitteil., p. 260, May, 1913.]

The precise level net of the United States. Eng. News, vol. 69, no. 16, p. 775 (Apr. 17, 1913).

The 17th general conference of the International Geodetic Association. Bull. Amer. Geog. Soc., vol. 45, no. 5, pp. 351-356 (May, 1913).

The adoption of the North American Datum. Bull. Amer. Geog. Soc., vol. 45, no. 8, p. 614 (Aug., 1913).

Determination of time, longitude, latitude and azimuth. Spec. Pub'n. 14, U. S. Coast Geod. Surv., 177 pp., 1913 [Rev. by David Rines, Science, vol. 38, no. 980, pp. 515-518 (Oct. 10, 1913).]

Isostasy (presented at Naval Observatory, Washington, Jan. 16, 1914).

Washington Society of Engineers (presented before Baltimore Soc. Eng., Feb. 24, 1914).

Isostasy and the size and shape of the earth (address at Atlanta, Georgia, with supplement, Dec. 20, 1913). Science, vol. 39, no. 1011, pp. 695-707 (May 15, 1914).

Isostasy in India (presented before Phil. Soc. Wash., Apr. 11, 1914). Abs., Jour. Wash. Acad. Sci., vol. 4, no. 10, pp. 245-249 (May 19, 1914).

Some geodetic evidence of isostasy. Abs., Jour. Wash. Acad. Sci., vol. 4, pp. 382-383 (1914).

The substitution of metal tapes and wires for bars in base measurements. Jour. Frank. Inst., vol. 177, no. 6, pp. 665-672 (June, 1914).

Recent development of precise leveling in the United States (presented to Amer. Ass'n. Adv. Sci., Sec. D., Philadelphia, Dec. 31, 1914).

Fourth general adjustment of the precise level net of the United States [with H. G. Avers]. Spec. Pub'n. 18, U. S. Coast Geod. Surv., 328 pp., 1914.

Primary triangulation along the 104th meridian and along the 39th parallel in Colorado, Utah and Nevada. Spec. Pub'n. 19, U. S. Coast Geod. Surv., 141 pp., 1914.

Precise leveling from Brighen, Utah, to San Francisco, California. Spec. Pub'n. 22, U. S. Coast Geod. Surv., 67 pp., 1914.

Symposium on the factors producing change in positions of strandline during Pleistocene and Post-Pleistocene (discussion Geol. Soc. Wash., Mar. 24, 1915). Abs., Jour. Wash. Acad. Sci., vol. 5, no. 12, p. 446 (June 19, 1915).

Astronomical and geodetic work in Alaska (unpublished address of June 23, 1915).

The geodetic work of the Coast and Geodetic Survey (presented before Phil. Soc. Wash., Apr. 10, 1915). Abs., Jour. Wash. Acad. Sci., vol. 5, no. 15, p. 557 (1915).

The errors in precise leveling due to irregular atmospheric refractions. Science, vol. 42, no. 1090, pp. 712-718 (Nov. 19, 1915).

Omaha's position on the earth's surface. The Omaha Bee, Feb., 1916.

Determination of the intensity of gravity on land in the United States (presented before Phil. Soc. Wash., Feb. 19, 1916). Abs., Jour. Wash. Acad. Sci., vol. 6, no. 7, pp. 187-188 (Apr. 4, 1916).

The one hundredth anniversary of the United States Coast and Geodetic Survey—Account of celebration. Science, vol. 43, no. 1115, pp. 655-656 (May 12, 1916).

Review of "The elements of surveying and geodesy" by W. C. Popplewell (London). Science, vol. 43, no. 1120, pp. 856-857 (June 16, 1916).

The contributions of geodesy to geography. Geog. Rev., vol. 2, no. 5, pp. 342-353 (Nov., 1916); Sci. Amer. Suppl., vol. 83, no. 2145, pp. 82-83 (Feb. 10, 1917).

Modern methods of precise leveling by the U. S. Coast and Geodetic Survey. Eng. and Contracting, vol. 47, no. 5 (Jan. 31, 1917).

The gravimetric survey of the United States. Proc. Nation. Acad. Sci., vol. 3, no. 3, pp. 171-177 (Mar., 1917).

Our present knowledge of isostasy (presented before Phil. Soc. Wash., Mar. 17, 1917). Abs., Jour. Wash. Acad. Sci., vol. 7, no. 9, pp. 269-270 (May 4, 1914).

Some evidences of isostasy (presented before Geol. Soc. Wash., Mar. 14, 1917). Abs., Jour. Wash. Acad. Sci., vol. 7, no. 10, pp. 311-312 (May 19, 1917).

Local versus regional distribution of isostatic compensation. Amer. Jour. Sci., vol. 43, pp. 471-475 (June, 1917).

Review of "Mean Sea Level at Datum for Elevations" by E. Lester Jones. Science, vol. 46, no. 1181, pp. 164-166 (Aug. 17, 1917).

Our present knowledge of isostasy from geodetic evidence. Jour. Geol., vol. 25, no. 5, pp. 422-445 (July-Aug., 1917); abs., Jour. Wash. Acad. Sci., vol. 7, pp. 267-268 (1917).

Investigations of gravity and isostasy. Spec. Pub'n. 40, U. S. Coast Geod. Surv., 196 pp. with 9 maps, 1917. [Abs. in Jour. Wash. Acad. Sci., vol. 7, no. 6, pp. 159-160 (1917).]

Specifications and instructions for preparation fire control and training maps. Chief Eng. U. S. Army, Reproduction Plant, Washington Barracks, D. C., 4610, 44 pp., 1917 (?).

Primary triangulation and precise leveling as done by the Coast and Geodetic Survey (presented before Phil. Soc. Wash., Jan. 5, 1918). Abs., Jour. Wash. Acad. Sci., vol. 18, no. 4, p. 105 (Feb. 19, 1918).

Oceanography in the Coast and Geodetic Survey (address at Cosmos Club, Washington, in honor of Dr. Frithof Nansen, Feb. 26, 1918).

The advantage of having maps. Memo. Mar 7, 1919.

Mapping the United States for civil and military needs (presented before Phil. Soc. Wash., Apr. 12, 1912). Abs., Jour. Wash. Acad. Sci., vol. 9, no. 15, pp. 447-449 (Sep. 19, 1919).

Report on the connection of the arcs of primary triangulation, Texas and Mexico. Spec. Pub'n. 54, U. S. Coast Geod. Surv., 93 pp., 1919.

Grid system for progressive maps in the United States [with O. S. Adams]. Spec. Pub'n. 59, U. S. Coast Geod. Surv., 227 pp., 1919. [Abs., Jour. Wash. Acad. Sci., vol. 9, no. 19, pp. 597-598 (Nov. 19, 1919).]

Board of Surveys and Maps of the Federal Government. Science, vol. 51, no. 1314, pp. 233-235 (Mar. 5, 1920).

Present status of geodesy and some of the problems of this branch of geophysics. Proc. Nation. Acad. Sci., vol. 6, no. 10, pp. 545-555 (Oct. 15, 1920). [Rep. Circ. Ser., Nation. Res. Council, no. 11, pp. 545-555 (Oct., 1920).]

The Kilauea Volcanic Observatory [with others] (Report of a Committee of the Nation. Acad. Sci.). Proc. Nation. Acad. Sci., vol. 6, no. 12, pp. 706-710 (Dec. 15, 1920).

Some geological conclusions from geodetic data. Proc. Nation. Acad. Sci., vol. 7, no. 1, pp. 23-28 (Jan., 1921). [Rev. in Sci. Amer. (Sep., 1921).]

The Pan Pacific Scientific Congress (presented before Phil. Soc. Wash., Oct. 23, 1920). Abs., Jour. Wash. Acad. Sci., vol. 11, no. 7, pp. 165-166 (Apr. 4, 1921).

The relation of isostasy to uplift and subsidence. Amer. Jour. Sci., vol. 2, no. 7, pp. 1-20 (July, 1921).

The topographical map of the United States. Geog. Rev., vol. 11, no. 3, p. 441 (July, 1921).

Research in geodetic work in the Pacific. Proc. First Pan-Pac. Sci. Conf., 1920, Bernice P. Bishop Mus., Spec. Pub'n. 7, Part 2, p. 452 ff. (1921).

Ocean currents and isostasy. Proc. First Pan-Pac. Sci. Conf., 1920, Bernice P. Bishop Mus., Spec. Pub'n. 7, Part 2, p. 503 ff. (1921).

The bearing of geodetic investigations on the geologic structure of the Pacific. Proc. First Pan-Pac. Sci. Conf., 1920, Bernice P. Bishop Mus., Spec. Pub'n. 7, Part 3, pp. 882-885 (1921).

Remarks on symposium of training scientists for Pacific work. Proc. First Pan-Pac. Sci. Conf., 1920, Bernice P. Bishop Mus., Spec. Pub'n. 7, Part 3, p. 926 (1921).

Scientific phases of charting waters and mapping the land (address before Amer. Ass'n. Adv. Sci., Sec. D, Toronto, Canada, 1921).

Mapping and charting (address before Amer. Ass'n. Adv. Sci., Sec. D, Toronto, Canada, 1921).

The yielding of the earth's crust (presented before Phil. Soc. Wash., Mar. 11, 1922). Ann. Rep. Smith. Inst'n. 1921, Pub'n. 2683, pp. 235-247, 1922; abs., Jour. Wash. Acad. Sci., vol. 12, no. 11, pp. 269-270 (June 4, 1922).

Theory of isostasy—A geological problem (lecture at Nation. Bur. Stand., Oct. 31, 1921). Bull. Geol. Soc. Amer., vol. 33, no. 2, pp. 273-286 (June 30, 1922).

The earth's crust and isostasy. Geog. Rev., vol. 12, no. 4, pp. 613-627 (Oct., 1922). [Rev. in Scot. Geog. Mag., vol. 39, no. 2 (Apr. 16, 1923).]

Geodetic operations in the United States, January 1, 1912, to December 31, 1921 (Rome report). Spec. Pub'n. 81, U. S. Coast Geod. Surv.,

26 pp., 1922. [Rev. by J. F. Hayford in Science, vol. 55, no. 1433, pp. 645-646 (June 16, 1922).]

Report on meetings of International Geodetic and Geophysical Union (presented before Phil. Soc. Wash., Oct. 21, 1922). Abs., Jour. Wash. Acad. Sci., vol. 13, no. 3, p. 43 (Feb. 4, 1923).

Ignorance of the world's natural resources as a cause for wars. Advocate of Peace, vol. 85, pp. 58-59 (Feb., 1923).

Board of Surveys and Maps. Science, vol. 57, no. 1476, pp. 436-437 (Apr. 13, 1923).

The present status of geodetic work in the United States and its value to geology. Amer. Jour. Sci., vol. 5, pp. 378-382 (May, 1923). [Abs. in Bull. Geol. Soc. Amer., vol. 34, no. 1, p. 74 (Mar., 1923).]

Review of Nansen's "The Strandflat and Isostasy." Amer. Jour. Sci., vol. 5, no. 29, pp. 428-432 (May, 1923).

Some recent progress in isostatic investigations (address before Amer. Geophys. Union, Apr. 19, 1923). Jour. Wash. Acad. Sci., vol. 13, no. 13, pp. 267-270 (July 19, 1923); abs., Bull. Nation. Res. Council, vol. 7, part 5, no. 41, pp. 95-96 (Jan., 1924).

Remarking of the initial point for surveys and maps in North America. Geog. Rev., vol. 13, no. 3, p. 465 (July, 1923).

Mapping the Pan-Pacific area. Bull. Pan-Pac. Union, 43, pp. 11-12 (1923).

Isostatic investigations and data for gravity stations established in the United States in 1915. 1923 (?).

Study of time errors in precise longtitude determinations by U. S. Coast and Geodetic Survey. Spec. Pub'n. 92, U. S. Coast Geod. Surv., 9 pp., 1923.

Geodetic and topographic mapping. Eng. News-Record, vol. 92, no. 3, p. 111 (Jan. 17, 1924).

Abnormal densities in the earth's crust disclosed by analysis of geodetic data. Geog. Jour., vol. 63, no. 1, pp. 26-33 (Jan., 1924). [Rev. in Amer. Jour. Sci., Apr., 1924, and in Nature, vol. 112, no. 2823, pp. 843-844 (Dec. 8, 1923).]

General conference of the International Geodetic and Geophysical Union (in "Report of Meeting of the International Geodetic and Geophysical Union and Its Sections Held at Rome, May 2-10, 1922"). Bull. Nation. Res. Council, vol. 7, part 5, no. 41, pp. 27-29 (Jan., 1924).

Report of the Section of Geodesy [in "Report of Meeting of the International Geodetic and Geophysical Union and Its Sections Held at Rome, May 2-10, 1922"] Bull. Nation. Res. Council. vol. 7, part 5, no. 41, pp. 29-32 (Jan., 1924).

Precise triangulation and level nets of United States. Eng. News-Record, vol. 92, no. 8, p. 330 (Feb. 21, 1924).

The accuracy of longitude determinations by the U. S. Coast and Geodetic Survey by wire signals and General Ferrié's proposed radio longitude net. Abs., Bull. Nation. Res. Council, vol. 7, part 5, no. 41, pp. 87-88 (Jan., 1924).

Some recent progress in isostatic investigations (presented at Fourth Annual Meeting of the American Geophysical Union, Washington, D. C., Apr., 1923, before the Section of Geodesy). Abs., Bull. Nation. Res. Council, vol. 7, part 5, no. 41, pp. 95-96 (Jan., 1924).

Earth movements in California as disclosed by triangulation (abs., with discussion by A. Keith, L. C. Graton, and A. C. Lawson). Bull. Geol. Soc. Amer., vol. 35, no. 1, pp. 60-62 (Mar. 30, 1924); abs., Pan-Amer. Geol., vol. 41, no. 2, pp. 134-135 (Mar., 1924).

Mountain building without loss of isostatic equilibrium (abs., with discussion by F. P. Shepard and W. H. Hobbs). Bull. Geol. Soc. Amer., vol. 35, no. 1, pp. 62-63 (Mar. 30, 1924); abs. Pan-Amer. Geol., vol. 41, no. 2, p. 135 (Mar., 1924).

Tertiary history of the north Atlantic Ocean (abs., with discussion by W. P. Woodring, Charles Schuchert, A. C. Lawson, and W. H. Hobbs). Bull. Geol. Soc. Amer., vol. 35, no. 1, pp. 84-85 (Mar. 30, 1924); abs., Pan-Amer. Geol., vol. 41, no. 2, pp. 142-143 (Mar., 1924).

The function of geodesy in surveying. Mil. Eng., vol. 16, no. 6, pp. 140-143 (Mar.-Apr., 1924).

Review of "Geodetic Evidence for the Supposed Westerly Drift of Greenland" by Col. Sir Charles Close. Amer. Jour. Sci., vol. 7, pp. 332-333 (Apr., 1924).

Stability of geodetic bench marks in United States—Results by U. S. Coast and Geodetic Survey in locations showing elevation change is of value to construction. Eng. News-Record, vol. 92, no. 18, p. 762 (May 1, 1924).

The use of geodetic measurements in detecting horizontal and vertical earth movements. Jour. Wash. Acad. Sci., vol. 14, no. 10, pp. 21-29 (May 19, 1924).

Isostasy in Holland. Amer. Jour. Sci., vol. 7, pp. 405-410 (May, 1924).

Gravity results in the MacKenzie Basin. Amer. Jour. Sci., vol. 7, pp. 411-412 (May, 1924).

The gravimetric survey of California. Pub'n. Astron. Soc. Pac., vol. 36, no. 211, pp. 107-111 (June, 1924).

The bearing of the theory of isostasy on some major geological problems. Jour. Frank. Inst., vol. 198, no. 2, pp. 181-200 (Aug., 1924). [Abs. in Mining Mag., London, Nov., 1924.]

On the size of the block of the earth's crust which may be independently in isostatic equilibrium. Jour. Wash. Acad. Sci., vol. 14, no. 15, pp. 355-362 (Sep. 19, 1924).

The importance of isostasy in geodetic research. Bull. Géodesique, Union Internat. Géod. Géophys., no. 3, pp. 194-213 (July-Sep., 1924).

Gravity observations on Indian Ocean and the results of their isostatic reduction. Nature, vol. 114, no. 2878, pp. 930-931 (Dec. 27, 1924).

The accuracy of longitude determinations by the Coast and Geodetic

Survey and General Ferrié's proposed longitude net. Proc. Pan-Pac. Sci. Cong., Australia, 1923, vol. 2, pp. 516-518 (1924).

Practical and scientific value of geodetic surveys. Proc. Pan-Pac. Sci. Cong., Australia, 1923, vol. 2, pp. 557-563 (1924).

The limiting depth of earthquake foci as indicated by seismic investigations. Proc. Pan-Pac. Sci. Cong., Australia, 1923, vol. 2, pp. 575-580 (1924).

Isostasy: Its importance in geological and geophysical investigations and research. Proc. Pan-Pac. Sci. Cong., Australia, 1923, vol. 2, pp. 1165-1168 (1924).

The theory of isostasy in its relation to major earth movements. Proc. Pan-Pac. Sci. Cong., Australia, 1923, vol. 2, pp. 1360-1366 (1924).

Isostatic investigations and data for gravity stations established in the United States since 1915. Spec. Pub'n. 99, U. S. Coast Geod. Surv., iv + 91 pp., 1924. [Rev. Nature, vol. 114, no. 2872, pp. 730-731 (1924); also Amer. Jour. Sci., vol. 8, no. 43, p. 98 (July, 1924).]

Geodetic operations in the United States and outlying possessions, January 1, 1922, to December 31, 1923 (Madrid report). Spec. Pub'n. 104, U. S. Coast Geod. Surv., iv + 28 pp., 1924.

Earth movements in California. Spec. Pub'n. 106, U. S. Coast Geod. Surv., 22 pp., 1924.

A gravimetric test of the "Roots of Mountains" theory. Ser. Pub'n. 291, U. S. Coast Geod. Surv., 8 pp., 1924.

Scientist suggests inventory of goods in world as surest guarantee of peace. Nation. News Serv. Weekly, Feb. 15, 1925.

Results of meeting of Section of Geodesy held at Madrid in September and October, 1924, which are of geological interest. Amer. Jour. Sci., vol. 9, pp. 180-186 (Feb., 1925).

The causes and prediction of earthquakes. Science, vol. 61, no. 1580, pp. 379-382 (Apr. 10, 1925).

Board of Surveys and Maps and aeronautics. Nation. Aeron. Ass'n. Rev., vol. 3, no. 4, pp. 56, ff. (Apr., 1925).

Isostasy at Madrid meetings of International Union of Geodesy and Geophysics. Pan-Amer. Geol., vol. 43, no. 5, pp. 337-344 (June, 1925).

Report of the Section of Geodesy [in "Report of the International Geodetic and Geophysical Union, and Its Sections at Madrid, October 1-10, 1924"]. Bull. Nation. Res. Council, vol. 10, part 3, no. 53, pp. 14-16 (July, 1925).

Scientists to weigh "floating" earth crust—Dutch geodesists will use submarine to test truth of new theory. New York Times, Sep. 6, 1925.

Scientists to test "drift" of continents. New York Times, Sep. 20, 1925; most of this article under title "Are the Continents Anchored?" appeared in The World Rev., Sep. 28, 1925.

The results of the meeting of the Section of Geodesy of the Internat. Union of Geod. and Geophys. of interest to astronomers. Pop. Astr., vol. 33, no. 7, pp. 423-430 (Aug.-Sep., 1925).

Volcanic science to make earth safer. New York Times, Oct. 11, 1925.

How mountains are made (radio talk, Apr. 15, 1925). Sci. Month., vol. 21, no. 10, pp. 404-408 (Oct., 1925).

Mapping the earth (talk before Washington Women's Club, Nov., 1925).

The ups and downs of the earth (radio talk, Dec. 3, 1925).

Isostasy in the Southern Pacific. Jour. Wash. Acad. Sci., vol. 15, no. 20, pp. 445-450 (Dec. 4, 1925). [Rev. in Nature, vol. 117, no. 2937, p. 246 (Feb. 13, 1926).]

The deflection of the vertical in Porto Rico. Jour. Wash. Acad. Sci., vol. 16, no. 2, pp. 29-31 (Jan. 19, 1926).

Geology from the isostatic viewpoint. Sci. Month., vol. 22, no. 1, pp. 5-18 (Jan., 1926).

Swinging pendulum measures longitude. Daily Sci. News Bull., Apr. 27, 1926.

Isostasy in Western Siberia. Amer. Jour. Sci., vol. 11, pp. 113-118 (Feb., 1926). [Rev. in Nature, vol. 117, no. 2941, p. 395 (Mar. 13, 1926).]

Eliminating drag effect in triangulation. Mil. Eng., vol. 18, no. 97, pp. 34-35 (Jan.-Feb., 1926).

Proposed theory, in harmony with isostasy, to account for major changes in the elevation of the earth's surface. Gerlands Beitr. Geophysik, vol. 15, no. 2, pp. 103-115 (1926).

Mapping the sky-ways. Western Flying, pp. 7, 28-29, Feb., 1926.

Notes on the Airy on "Roots of Mountains" theory. Science, vol. 63, no. 1632, pp. 371-374 (Apr. 9, 1926).

Earthquakes from the isostatic viewpoint. Jour. Wash. Acad. Sci., vol. 16, no. 9, pp. 245-250 (May 4, 1926).

The work of the Coast and Geodetic Survey. Cornell Civ. Eng., p. 193, May, 1926; rep. (somewhat abridged) under title "The Coast and Geodetic Survey," Tech. Eng. News, Mass. Inst. Tech., pp. 168-171, 188, 200 (Oct., 1926).

Submarine used to study gravity of ocean beds. U. S. Daily News, Sep. 16, 1926.

Pendulum observations between Holland and Java. Amer. Jour. Sci., vol. 12, pp. 273-274 (Sep., 1926).

Isostatic reductions of Spanish gravity stations. Amer. Jour. Sci., vol. 12, pp. 354-356 (Oct., 1926). [Rev. in Nature, vol. 119, no. 2983 (Jan. 1, 1927).]

Long lines of triangulation. Geog. Rev., vol. 16, no. 4, pp. 638-641 (Oct., 1926).

Discussion following Symposium on the constitution of the earth and the inferences to be drawn from it [with others]. Bull. Nation. Res. Council, vol. 11, part 2, no. 56, pp. 33-39 (Nov., 1926).

The trend of geodesy. Bull. Nation. Res. Council, vol. 11, part 2, no. 56, pp. 58-61 (Nov., 1926).

Relation of earthquakes to isostasy. Bull. Nation. Res. Council, vol. 11, part 2, no. 56, pp. 72-73 (Nov., 1926).

The Aleutian Islands from the standpoint of the geodesist and chart-maker. Bull. Nation. Res. Council, vol. 11, part 2, no. 56, pp. 121-124 (Nov., 1926).

The relation of isotasy to seismology. Amer. Jour. Sci., vol. 12, pp. 415-418 (Nov., 1926).

Use of gravity pendulum as a timepiece. Ser. Pub'n. 356, U. S. Coast Geod. Surv., 4 pp., 1926.

Isostatic condition of the United States, as indicated by groups of gravity stations. Ser. Pub'n. 366, U. S. Coast Geod. Surv., 11 pp., 1926.

Use of the gravity pendulum in the search for petroleum. Oil and Gas Jour., vol. 25, no. 35, pp. 80-84 (Jan. 20, 1927).

Review of "Schwerekraft und isostatische Kompensation in Norwegen" by W. Heiskanen. Amer. Jour. Sci., vol. 13, pp. 87-90 (Jan., 1927).

Measurement of length of line used in determination of velocity of light. Astroph. Jour., vol. 65, no. 1, pp. 48-56 (Jan., 1927); also rep. as App. III, in Cont. Mt. Wilson Obs., no. 329, pp. 14-22 (1927).

Importance of isostasy to mapping. Mil. Eng., vol. 19, no. 103, pp. 19-23 (Jan.-Feb., 1927).

The part played by isostasy in geophysics and geology (presidential address, Phil. Soc. Wash., Jan. 8, 1927). Jour. Wash. Acad. Sci., vol. 17, no. 5, pp. 101-117 (Mar. 4, 1927).

Importance of gravity observations in disclosing sub-surface structures. Bull. Assoc. Eng. Soc. (Illinois), Apr., 1927.

Isostasy. Book published by E. P. Dutton and Co., 681 Fifth Avenue, New York, xvi + 275 pp., 39 figs., July, 1927.

The effect of the shape of the geoid on values of gravity at sea. Amer. Jour. Sci., vol. 14, pp. 222-227 (Sep., 1927).

Some phases of the vertical movement of crustal material. Amer. Jour. Sci., vol. 14, pp. 253-258 (Oct., 1927).

Rapport sur l'isostasie (Report on isostasy). Travaux de la Section de Géodésie, Union Internat. Géod. Géophys., Madrid, 1924, vol. 4, 38 pp. (1927).

Geodetic operations in the United States, January 1, 1924, to December 31, 1926 (Prague report). Spec. Pub'n. 134, U. S. Coast Geod. Surv., iii + 34 pp., 1927.

The triangulation of the United States. Cornell Civ. Eng., vol. 36, no. 5, pp. 117-121 (Feb.-Mar., 1928).

An early comment on isostatic compensation. Amer. Jour. Sci., vol. 15, pp. 433-434 (May, 1928).

Isostasy and geological thought. Sci. Month., vol. 26, pp. 385, ff. (May, 1928).

Gravity in Western Canada. Amer. Jour. Sci., vol. 16, no. 93, pp. 263-266 (Sep., 1928).

The triangulation of North America. Geog. Jour. (London), vol. 72, no. 4, pp. 348-356 (Oct., 1928).

Seismology (Comments on)—Report of Advisory Committee, Carnegie

Institution of Washington. Carnegie Inst. Wash. Year Book no. 27, 1927-28, pp. 411-412 (Dec. 13, 1928).

The reliability of the spheroid derived by the isostatic method. Bull. Géodésique, Union Internat. Géod. Géophys., no. 20, pp. 495, ff. (Oct.-Dec., 1928).

Comments of Wegener hypothesis (Chapter in "Theory of Continental Drift," pub. by Amer. Ass'n. Petrol. Geol., pp. 178-186, 1928).

The importance of gravity determinations at sea. Proc. Pan-Pac. Sci. Cong., Japan, 1926, vol. 1, pp. 631-634 (1928).

Rapport sur l'isostasie (Report on isostasy). Travaux de la Section de Géodésie, Union Internat. Géod. Géophys., Prague, août 29-septembre 10, 1927, vol. 6, 32 pp. (1928).

Causes and prediction of earthquakes (Chapter in "Papers in Honor of Charles Frederick Johnson—Trinity College, 1928"). 1928.

Comparison of old and new triangulation in California. Spec. Pub'n. 151, U. S. Coast Geod. Surv., 50 pp., 1928. [Rev. in Nature, vol. 123, no. 3102, pp. 583-584 (Apr. 13, 1929).]

The stability of the earth's crust as tested by triangulation. Abs., Jour. Wash. Acad. Sci., vol. 19, no. 4, pp. 88-89 (Feb. 19, 1929).

Leveling up Mt. Whitney. Sierra Club Bull., Feb., 1929.

Weighing the earth from a submarine. Sci. Amer., vol. 140, pp. 218-221 (Mar., 1929). [Trans. in Boletin de Pescas, Instituto Español de Oceanografía, Apr., 1929.]

Possible origin of oceans and continents. Gerlands Beitr. Geophysik, vol. 21, no. 2/3, pp. 178-182 (1929).

Isostasy and geological thought. Sci. Month., vol. 28, no. 5, pp. 385-392 (May, 1929).

Carey V. Hodgson. Science, vol. 69, no. 1799, pp. 657-658 (June 21, 1929).

The Ohio arc of first-order triangulation. Bull. Géodesique, Union Internat. Géod. Géophys., no. 22, pp. 51-53 (Apr.-June, 1929).

The figure of the earth derived from triangulation methods. Amer. Jour. Sci., vol. 18, pp. 53-59 (July, 1929).

Au sujet des prismes verticaux de la terre ayant même masse. C.-R. Acad. Sci., vol. 189, no. 9, pp. 350-352 (Aug., 1929) and Erratum, ibid., p. 412, Sep., 1929.

Activities of the Surveying and Mapping Division of the Society. Proc. Amer. Soc. Civ. Eng., vol. 55, no. 7, pp. 1899-1901 (Sep., 1929) [Rep. by W. and L. E. Gurley Co., 4 pp., 1929.]

Note on a change, by the Coast and Geodetic Survey, in precise leveling methods. Bull. Géodésique, Union Internat. Géod. Géophys., no. 23, pp. 98-100 (July-Sep., 1929).

Tilting of mean sea level. Gerlands Beitr. Geophysik., vol. 23, no. 2, pp. 97-98 (1929). [Rev. by McArthur in Pac. Eng., Feb., 1930.]

Notable progress in surveying instruments. Sci. Month., vol. 29, no. 11, pp. 402-406 (Nov., 1929).

Zones of weakness in the earth's crust. Science, vol. 70, no. 1825, pp. 589-592 (Dec. 20, 1929).

An approximate method of making the isostatic reduction of gravity values. Bull. Géodésique, Union Internat. Géod. Géophys., no. 24, pp. 210-222 (Oct.-Dec., 1929).

Geography. Pop. Sci. Month., vol. 116, no. 1, p. 21 (Jan., 1930).

The scientific and practical value of triangulation. Jour. Wash. Acad. Sci., vol. 20, no. 4, pp. 53-59 (Feb. 19, 1930).

The status and importance of isostasy. Min. Metal., vol. 11, no. 278, pp. 93-95 (Feb., 1930). [Rep. in Oil and Gas Jour., Feb., 1930.]

Discurso del sr. Dr. William Bowie, representando a la Sociedad Geográfico Nacional, pronunciado en la Assemblea del Instituto Pan-Americano de Geografía e Historia el 7 de septiembre de 1929. Rev. Soc. Estudios Astronómicos y Geofísicos, México, D. F., vol. 2, no. 1, pp. 5-11 (Feb., 1930).

The triangulation system of the United States. Sci. Month., vol. 30, pp. 127-131 (Feb., 1930).

Bench marks established on trees. Eng. News-Record, vol. 104, no. 3, pp. 532-533 (Mar. 27, 1930).

Status and progress in the art of surveying and mapping. Proc. Amer. Soc. Civ. Eng., vol. 56, no. 3, pp. 453-463 (Mar., 1930). [Rep. as "Progress in the Art of Surveying and Mapping," in Pac. Eng., 12 pp., Sep., 1930.]

Crustal changes due to moon's formation. Gerlands Beitr. Geophysik, vol. 25, no. 2, pp. 137-144 (1930).

International co-operation in geographical work (Mexican address). Science, vol. 71, no. 1843, pp. 425-429 (Apr. 25, 1930).

Test of the Wegener hypothesis by means of geodetic data in India. Science, vol. 71, no. 1844, pp. 459-460 (May. 2, 1930).

Topographic map of entire country grows in year. U. S. Daily, June 17, 1930.

Azimuths on the Mississippi River arc of triangulation. Bull. Géodésique, Union Internat. Géod. Géophys., no. 26, pp. 33-39 (Apr.-June, 1930).

The origin of the moon. Mil. Eng., vol. 22, no. 123, pp. 199-203 (May-June, 1930).

Accomplishments in field geodesy during the year April, 1928, to April, 1929. Trans. Amer. Geophys. Union 1929 and 1930, pp. 36-40 (June, 1930).

Progress in geodetic work, April, 1929, to April, 1930. Trans. Amer. Geophys. Union 1929 and 1930, pp. 129-135 (June, 1930).

Some international problems in geodesy. Bull. Géodésique, Union Internat. Géod. Géophys., no. 26, pp. 33-39 (Apr.-June, 1930).

Discussion on "Exploring the Hidden Earth" with George W. Gray. World's Work, July, 1930.

Meeting of the International Union of Geodesy and Geophysics, Stockholm, Aug., 1930.

Elements of isostasy—Observations and interpretation. Sci. Month., vol. 31, no. 2, pp. 163-175 (Aug., 1930).

La importancia de la astronómia en las triangulaciones. Rev. Soc. Estudios Astronómicos y Geofísicos, vol. 2, no. 4, pp. 59-64 (Sep., 1930).

Approximate value of the depth of compensation from Japanese gravity data. Amer. Jour. Sci., vol. 20, pp. 220-222 (Sep., 1930).

Tilting of mean sea level. Illinois Eng., Oct., 1930.

Modernizing triangulation practice. Civ. Eng., vol. 1, no. 3, pp. 189-193 (Dec., 1930). [Feb., Mar., and Apr. numbers Civ. Eng. contain letters concerning this paper.]

Geodetic work done in California by U. S. Coast and Geodetic Survey (Report Advisory Committee in Seismology, Carnegie Institution of Washington). Carnegie Inst'n. Wash. Year Book 1929-30, no. 29, pp. 428-430 (Dec., 1930).

Report on isotasy (prepared for General Assembly Internat. Union Geod. Geophys., Stockholm, Aug., 1930). Mimeogr. ed., 27 pp., 1930.

Geodetic operations in the United States, January 1, 1927, to December 31, 1929 (Stockholm report). Spec. Pub'n. 166, U. S. Coast Geod. Surv., iv + 38 pp., 1930.

Notes on the activities and personnel of Coast and Geodetic Survey; progress on expanded plan for control surveys. Jour. Ass'n. Amer. State Geologists, Jan., 1931.

Modernizing triangulation practice—Improved instruments and equipment by Geodetic Survey. [Rev. in Civ. Eng., vol. 1, p. 429 (Feb., 1931).]

Isostasy (Chapter 7 of vol. 2 of series "Physics of the Earth" on "Figure of the Earth"). Bull. 78, Nation. Res. Council, pp. 103-115 (Feb., 1931).

Shaping the earth [presidential address. Wash. Acad. Sci., Jan. 15, 1931]. Jour. Wash. Acad. Sci., vol. 21, no. 6, pp. 103-125, Mar. 19, 1931. [Rep. in Ann. Rep. 1931, Smith. Inst'n., pp. 325-345, 1932.]

The determination of astronomical longitudes at some triangulation stations. Bull. Géodésique, Union Internat. Géod. Géophys., no. 29, pp. 52-54 (Jan.-Mar., 1931).

Raoul Gautier. Science, vol. 73, no. 1900, pp. 579-580 (May 29, 1931).

The preservation of old surveying instruments. Mil. Eng., vol. 23, no. 128, pp. 114-116 (Mar.-Apr., 1931).

Thickness of the ice in Greenland. Amer. Jour. Sci., vol. 21, pp. 406-408 (May, 1931).

The earth as an engineering structure (radio talk over Columbia Broadcasting System, Jan. 30, 1931). Sci. Month., vol. 32, no. 5, pp. 457-460 (May, 1931); U. S. Coast Geod. Surv., Bull. Ass'n. Field Eng., no. 3, pp. 63-66 (1931).

Scientists consider recent progress in studies of earth, geodetic survey extends progress of field work, and how knowledge of earth's shape aids map making. U. S. Daily, May, 1931.

Progress in geodetic work during the past year. Trans. Amer. Geophys. Union 1931, pp. 51-58 (June, 1931).

Geodetic work lays the basis for study of earth-movements. Trans. Amer. Geophys. Union 1931, pp. 65-66 (June, 1931).

Triangulation. Sci. Amer., vol. 144, pp. 369-373 (June, 1931). [Spanish trans. under title "Triangulaciones—Como y por que se Hacen", Ingeniera (Mexico), pp. 243, ff., July 1931.]

Basis of surveys over country being adjusted. U. S. Daily, 1 p., Sep. 16, 1931.

Hitching the shore line to the stars. Bull. Mer. Mar., pp. 6-7, Oct., 1931.

Mapping our country. Cornell Civ. Eng., Dec. 23, 1931.

Azimuth lines established at triangulation station. Bull. Géodésique, Union Internat. Union Géod. Géophys., no. 32, p. 311 (Oct.-Dec., 1931).

Sur une cause possible des tremblements de terra ne se manifestent pas a la surface du globe. C.-R., Acad. Sci., vol. 194, no. 6, pp. 507-508 (Feb. 8, 1932).

A method of testing Airy and Pratt isostasy. Gerlands Beitr. Geophysik, vol. 36, pp. 171-176 (1932).

Comments on isostasy made by authors of geological and geophysical books and papers. Nation. Res. Council, 49 pp., Apr., 1932 (mimeogr.).

Reports of Committee on Improvement in Gravity Instruments. Nation. Res. Council, Div. Geol. Geog., Apr., 1932 (mimeogr.).

What can ocean surveys accomplish? Philadelphia Ledger, Apr. 22, 1932.

Working with maps. New York Times, May 15, 1932.

Geodetic work accomplished from May 1, 1931, to April 30, 1942. Trans. Amer. Geophys. Union 1932, pp. 81-85 (June, 1932).

The standard theodolite of U. S. Coast and Geodetic Survey. Civ. Eng., vol. 2, no. 6, pp. 355-357 (June, 1932).

The great control surveys of the United States. U. S. Daily, July 26, 1932.

Locating geographic positions of boundary lines. U. S. Daily, Sep. 23, 1932.

Can the problems of oceans and continents be solved? Assoc. Press, Oct. 4, 1932.

The surfaces of the earth. Jour. Geol., vol. 40, no. 8, pp. 739-744(Nov.-Dec., 1932).

Rapport sur l'isostasie (Report on isostasy). Travaux de la Ass'n. Géodésie, Union Internat. Géod. Géophys., Stockholm, 11-23 août, 1930, vol. 8 (1932).

Gravity data (in volume on "Yellowstone-Beartooth-Big Horn region). 16th Internat. Geol. Cong., 1933, Guidebook 24, Excursion C-2, pp. 63-64, 1932.

Pratt or Airy? (Isostasy). Jour. State Russian Geog. Soc., vol. 65, no. 1, pp. 13-23 (1933). [In Russian.]

Early American boundary surveys. Civ. Eng., vol. 3, no. 2, p. 96 (Feb., 1933).

Recent developments in gravity apparatus. Science, vol. 77, no. 1995, pp. 308-310 (Mar. 24, 1933).

Triangulating the Continent of North America. Eng. News-Record, vol. 110, no. 13, pp. 405-406 (Mar. 30, 1933).

Report of Committee on Isostasy. Ann. Rep. 1932-33, Nation. Res. Council, Div. Geol. Geog., App. I, Apr., 1933 (mimeogr.).

Precise geodetic measurements and their relation to seimological investigations. Trans. Amer. Geophys. Union 1933, pp. 284-286 (June, 1933).

Preserve the landmarks. Eng. News-Record, vol. 111, no. 6, p. 172 (Aug. 10, 1933).

One hundred years of control surveys. Civ. Eng., vol. 3, pp. 467-478 (Aug., 1933).

The use of Laplace azimuths in the adjustment of triangulation. Bull. Géodésique, Union Internat. Géod. Géophys., no. 39, pp. 237-249 (July-Aug., 1933).

Protect the surveying mark (orig. mss. title "Landmarks too valuable not to be carefully kept"). The State, Columbia, S. C., Oct. 15, 1933, and other newspapers.

Surveying and mapping the United States. Mil. Eng., vol. 25, no. 143, pp. 386-389 (Sep.-Oct., 1933).

Geodetic operations in the United States, January 1, 1930, to December 31, 1932 (Lisbon report). Spec. Pub'n. 178, U. S. Coast Geod. Surv., 25 pp., 1933.

Geodetic surveying (Chapter in "Vocational Guidance in Engineering Lines"). Amer. Ass'n. Eng., 1933 (?).

Gravity stations on the Nile Delta. Science, vol. 79, no. 2053, pp. 410-411 (May 4, 1934).

A comparison of isostasy in India and in the United States and Southern Canada. Gerlands Beitr. Geophysik, vol. 41, no. 2, pp. 250-260 (1934). [Abs. in Zs. Geophysik, vol. 10, no. 5/6, pp. 93-94 (1934).]

Planning without maps. Eng. News-Record, vol. 113, no. 2, p. 57 (July 12, 1934).

Resurveying the coast of Connecticut. Ann. Rep., Conn. Soc. Civ. Eng., pp. 44, ff., July, 1934.

Control surveys furnish framework for airway maps. Air Commerce Bull., vol. 6, no. 5, pp. 111-112 (Nov. 15, 1934).

The use in the United States of geodetic control surveys in testing the stability of the earth's surface (presented before Pac. Sci. Cong., Vancouver, Canada, June, 1933). Proc. Pac. Sci. Cong., vol. 2, pp. 1279-1283 (1934).

Isostasy and its importance in geological and geophysical investigations and research (presented before Pac. Sci. Cong., Vancouver, Canada, June, 1933). Proc. Pac. Sci. Cong. 1933, vol. 2, pp. 1165-1168 (1934). [Abs. in Pan-Amer. Geol., vol. 66, no. 3, pp. 232-233 (Oct., 1936).]

Working with maps (address before South Carolina Society of Engineers June 15, 1934). Geodetic Letter, no. 8, 1934.

Fundamental geodetic surveys in the United States nearing completion (address before Nation. Acad. Sci., Nov. 19, 1934). Proc. Nation. Acad. Sci., vol. 21, no. 1, pp. 32-36 (Jan. 15, 1935). [Rev. in Nature, vol. 135, no. 3414, p. 559 (Apr. 6, 1935).]

Appui donné a la Géodésie par le Gouvernement des États-Unis de l'America du Nord. C.-R. Acad. Sci., vol. 200, no. 5, pp. 366-368 (Jan. 28, 1935).

The work of the Coast and Geodetic Survey (lecture before Ass'n. Amer. State Geol., Washington, Feb. 23, 1935).

Geodetic control net aided by PWA-financed work. Eng. News-Record, vol. 114, no. 9, pp. 316-317 (Feb. 28, 1935).

The present status of geodetic surveys (lecture at Nation. Bur. Stand., Mar. 1, 1935).

The value of maps to all of us (radio interview between Prof. J. C. Dodds and W. Bowie at Iowa State College, Ames, Iowa, Mar. 6, 1935).

Review of "Measurements of Gravity over the Nippon Trench." Science, vol. 81, no. 2100, p. 309 (Mar. 29, 1935).

The work of the Coast and Geodetic Survey in Texas. Eleventh ann. short course in highway engineering, College Station, Texas, Apr. 13, 1935.

Dust storms cover survey monuments. Press release, Apr. 17, 1935.

Survey monuments do not mark buried treasure. Press release, Apr. 20, 1935.

Surveying and mapping entering a new era (presented in Seventh Ann. Inst. Government, Los Angeles, June 10, 1935).

Significance of gravity anomalies at stations in the West Indies. Bull. Geol. Soc. Amer., vol. 46, no. 6, pp. 869-878 (June 30, 1935).

Astronomical work of the United States Coast and Geodetic Survey. Astro. Soc. Pac., leaflet 77 (June, 1935).

The geodetic work of the Coast and Geodetic Survey and its uses (lecture before Iowa Eng. Soc. and Eng. Ext. Serv., Iowa State College, Mar., 1935). Geodetic Letter, vol. 2, no. 6, pp. 4-13 (June, 1935).

Status of national control surveys. Bull. Amer. State Geol., July 1, 1935.

Surveying and mapping in the curricula of departments of civil engineering of our universities. Sent to Civ. Eng., July 29, 1935.

Gravity at sea (embodied in Report of Special Committee on Geophysical and Geologic Study of Oceanic Basins). Trans. Amer. Geophys. Union 1935, part I, p. 7 (Aug., 1935).

Mapping the country. Trans. Amer. Geophys. Union 1935, part I, pp. 61-62 (Aug., 1935).

Isostasy (lecture before Iowa Eng. Soc. and Eng. Ext. Serv., Iowa State College, Ames, Iowa, Mar. 6, 1935). Sci. Month., vol. 41, no. 3, pp. 234-239 (Sep., 1935).

The use of triangulation in boundary surveys. Bull. Pan-Amer. Union, vol. 69, pp. 694-699 (Sep., 1935).

Use of ball bearings as leveling turning points. Bull. Géodésique, Union Internat. Géod. Géophys., no. 47, pp. 367-370 (July-Sep., 1935).

Absolute gravity survey in Gulf Coast States would be of great value to petroleum industry [with W. L. Baker and others]. Oil Weekly, vol. 79, no. 9, pp. 38, 39, 42, 44, 46 (Nov. 11, 1935).

The origin of oceans and continents. Sci. Month., vol. 41, no. 5, pp. 444-449 (Nov., 1935).

U. S. Coast and Geodetic Survey helps to map nation. Bull. Balto. Eng. Club., vol. 10, no. 6, pp. 5-9 (Dec., 1935).

Science in the United States Coast and Geodetic Survey (presented before Nation. Acad. Sci., Apr. 22, 1935). Jour. Frank. Inst., vol. 220, no. 6, pp. 719-731 (Dec., 1935).

Basic survey data essential to industry. Oil Weekly, vol. 79, no. 9, pp. 40-46 (1935).

Can the national control surveys help engineers? Illinois Soc. Eng., 1935 (?).

Working with maps (address before South Carolina Engineering Society, meeting June 14-15, 1934, at Charleston, S. C. [Pub. as "Importancia de las cartas geograficas", Pan-Amer. Inst. Geog. e Historia, Pub'n. 16 (1935).]

Control survey costs lowered by engineering parties of the Coast and Geodetic Survey. 1935.

Employment on control surveys. 1935.

Astronomical work of the United States Coast and Geodetic Survey. 1935.

The national mapping plan (address before Ass'n. State Geol., Oct. 1, 1935). Jour. Ass'n. Amer. State Geol., vol. 6, no. 4, pp. 8-10 (Jan., 1936).

The national mapping plan of the National Resources Board (address before Nation. Acad. Sci., Charlottesville, Virginia, Nov. 20, 1935). Science, vol. 83, no. 2144, pp. 94-95 (Jan. 31, 1936).

No maps in a mapping age. Civ. Eng., vol. 6, no. 2, pp. 88-90 (Feb., 1936); also in Amer. Soc. Photogrammetry, Jan.-Mar., 1936, Canadian Surveyor, Apr., 1936, Geodetic Letter, June, 1936, Jour. Ass'n. Chinese Amer. Eng., p. 298, Sep.-Oct., 1936, Louisiana Conserv. Rev., Jan., 1937.

Status of geodetic surveys in the United States of North America. Amer. Soc. Civ. Eng., Feb., 1936.

Benefits of Arkansas boundaries. Arkansas Gaz., vol. 12, no. 5, pp. 1-2 (Mar. 29, 1936).

Status of work of the Coast and Geodetic Survey of importance to geologists. Jour. Ass'n. Amer. State Geol., vol. 7, no. 2, pp. 21-28 (Apr. 1, 1936).

State co-operation in Geodetic Survey to bring topographic maps up to date: The leveling of California. Cal. Highways and Pub. Works, pp. 22-24, Apr., 1936.

Science in the United States Coast and Geodetic Survey. Hydrog. Rev., Internat. Hydrog. Bur., vol. 13, p. 99 (May, 1936).

Geodetic surveys in the United States of North America. Jour. Ass'n. Chinese Amer. Eng., vol. 17, pp. 99, ff. (Mar.-Apr., 1936).

Vertical movements of earth's crust as determined by leveling. Jour. Geol., vol. 44, no. 3, pp. 387-395 (Apr.-May, 1936).

Local densities affect values of gravity. Jour. Geol., vol. 44, no. 4, pp. 510-514 (May-June, 1936).

Coast Geodetic Survey—Explanation of its hydrographic work being with geodetic work (communication to Geodetic Survey of Canada, July 6, 1936).

The place of geodesy in geophysical research (paper in Symposium on recent trends in geophysical research). Trans. Amer. Geophys. Union 1936, part I, pp. 15-20 (July, 1936).

More levels and maps needed. Eng. News-Record, vol. 117, no. 7, p. 247 (Aug. 13, 1936).

Maps aid engineering and planning (address before Eng. Club of Trenton, New Jersey, Dec. 10, 1936).

Highway location can be helped by geodetic surveys. Texas Parade, Dec., 1936.

Geodetic operations in the United States, 1933-1935. Spec. Pub'n. No. 207, U. S. Coast Geod. Surv., 25 pp., 1936.

Geodetic work of the United States of America. Jour. Russian Geog. Soc., 1936 (?).

Maps aid oil and gas industries. Oil and Gas Jour., 1936.

The place of surveying and mapping in the curricula of educational institutions (report as Chairman, Committee on Surveying and Mapping in Engineering Industries, Division of Engineering and Mapping, Amer. Soc. Civ. Eng.). 1936 (?).

The need for maps (talk before British Ass'n. Adv. Sci., Blackpool, England, Sep. 14, 1936). Mil. Eng., vol. 29, no. 163, pp. 42-43 (Jan.-Feb., 1937).

Isostasy (address before British Ass'n. Adv. Sci., Blackpool, England, Sep. 10, 1936). Sci. Month., vol. 44, no. 4, pp. 353-357 (Apr., 1937).

Map makers and map users. Civ. Eng., vol. 7, no. 4, pp. 273-276 (Apr., 1937).

Response on occasion of exercise in honor of Major William Bowie on his retirement from the Coast and Geodetic Survey held on Jan. 4, 1937. Bull. Géodésique, Union Internat. Géod., Géophys., no. 54, pp. 162-168 (Apr.-June, 1937).

The need for maps. Jour. Ass'n. Chinese Amer. Eng., Mar.-Apr., 1937.

Address as President of Internat. Union Geod. Geophys. at Edinburgh, Sep. 17, 1936. Union Internat. Géod. Géophys. Sixième Assemblée Générale réunie à Édinbourg, 14-25 septembre 1936, pp. 30-38 (1937).

Map makers and map users. Jour. Ass'n. Chinese Amer. Eng. vol. 18, no. 5, pp. 336-346 (Sep.-Oct., 1937).

The objectives of the Pan-American Institute of Geography and History. Pan-Amer. Inst. Geog. History, 8 pp., 1937.

Topographic maps a national asset. Virginia Eng., 1937.

Geologists need maps. Min. Metal., vol. 19, no. 374, pp. 99-101 (Feb., 1938).

Taking stock of national mapping. Civ. Eng., vol. 8, no. 4, pp. 266-267 (Apr., 1938).

Survey and map control (lecture before Inst. Government, Los Angeles, June, 1938).

Map projection (lecture before Inst. Government, Los Angeles, June, 1938).

Adjustments in the crust of the earth (lecture before Inst. Government, Los Angeles, June, 1938).

National mapping. Eng. Bull., Colorado Soc. Eng., July, 1938.

Otto Hilgard Tittmann. Science, vol. 88, no. 2283, pp. 292-294 (Sep. 30, 1938).

Shape and size of the earth. Sci. Month., vol. 47, no. 12, pp. 506-510 (Dec., 1938).

Use of triangulation. Mil. Eng., vol. 30, no. 174, pp. 397-399 (Nov.-Dec., 1938).

Life work in geodesy. Lehigh Alumni Bull., Mar., 1939.

The importance of co-operation in international science. Finnisches Geodätisches Inst. 1918-1938. Veroff. no. 261, p. 15 (1939).

The gravity anomaly, an important factor in earth science. Science, vol. 91, no. 2355, pp. 158-160 (Feb. 16, 1940).

Isostasia. Rev. Geografíca, Inst. Geog. e Historia, vol. 1, no. 1, pp. 12-19 (Jan., 1941).

Memorandum of Biographical Accounts of William Bowie Consulted

William Bowie. *Bull. Géodesique,* No. 54, pp. 150-188 (1937). [Includes: William Bowie, by F. A. Vening Meinesz and G. Perrier; International Scientist honored, William Bowie retires from Coast and Geodetic Survey, Press Memorandum of January 4, 1937; Exercises in Honor of Major William Bowie on his retirement from the Coast and Geodetic Survey held on January 4, 1937, with remarks by Commander C. L. Garner, H. G. Avers, W. D. Lambert, Lieutenant H. W. Hemple, Commander J. H. Hawley, and reply by Major Bowie; Papers by Dr. William Bowie which appeared in Special Publications of the Coast and Geodetic Survey; and List of Articles and Papers by Dr. William Bowie.]

Captain William Bowie (Retired). Report No. 2185, submitted by E. J. Hart for the Committee on Merchant Marine and Fisheries (to accompany S. J. Res. 247), House of Representatives, 75th Congress, Third Session, April 21, 1938, 6 pp.

Dr. William Bowie by H. St. J. L. Winterbotham. *Nature*, vol. 146, p. 645 (Nov. 15, 1940).

William Bowie by C. R. Longwell. *Amer. Jour. Sci.*, vol. 238, pp. 889-890 (1940).

William Bowie. Obituary in *Bull. Coast and Geodetic Survey*, 1940.

El Dr. William Bowie by P. C. Sanchéz. *Revista de Historia de America*, no. 9, pp. 1-4 (Aug., 1940).

Memorial to William Bowie by N. H. Heck. *Proc. Geol. Soc. Amer.*, 1940, pp. 163-166 (1941).

William Bowie. *Geog. Rev.*, vol. 31, pp. 156-157 (1941).

William Bowie as an Isostasist and as a Man by W. Heiskanen. *Trans. Amer. Geophys. Union*, vol. 30, no. 5, pp. 629-635 (Oct., 1949).

Also consulted were:

Various publications of William Bowie issued by the United States Coast and Geodetic Survey during 1912-1937, and correspondence between Professor W. H. Burger of Northwestern University and William Bowie.

Much helpful information was supplied by Dr. Bowie's old associates, namely, Captain Clement L. Garner (Bowie's immediate successor as Chief of the Division of Geodesy), Captain H. W. Hemple, Hugh C. Mitchell, C. H. Swick, J. A. Duerksen, and others at the Coast and Geodetic Survey. Librarian H. D. Harradon of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, a long-time friend of Dr. Bowie, assembled much of the material for this memoir.

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1873–1941

BY MARY S. GARDINER

David Hilt Tennent was born on May 28, 1873, in Janesville, Wisconsin, one of the younger children in the large family of Thomas and Mary Hilt Tennent. He was of Irish and American ancestry. His father, as a young man of 19, left the town of Newtonhamilton in County Armagh, Ireland, to come to the United States to make his living. In so doing he followed the example of other members of the Tennent family, devout Presbyterian ministers, who had emigrated to the United States a hundred years earlier. William Tennent created and to a great extent built with his own hands the little theological school—Log College at the Forks of Neshaminy near the Pennsylvania-New Jersey border—in which a notable group of young men including his own sons Gilbert, William and John, were trained as Presbyterian ministers and from which they went forth to preach the Gospel. Although not in direct line of descent from them, David Tennent was always proud of the part these representatives of his family had played in the spread of religion and in the development of scholarship in America.

David Tennent's father, Thomas, settled in Cambridge, Massachusetts, married and had two children. Later he went to Janesville, Wisconsin, where he married a second time. His second wife was Mary Hilt, a Philadelphian by birth, and David was the fourth of her six children. Thomas Tennent was a contractor and the family life was simple, even austere. Each child had his share of tasks that had to be satisfactorily done and each had to earn what he could for his own needs, with little left for the satisfaction of even small desires. The Tennent children had a rigorous and not particularly happy childhood, and they early learned to accept the responsibilities of life and to meet them punctiliously and uncomplainingly.

David Tennent received his early education in the public schools of Janesville. He was, as far back as he could remember, fired by anything scientific and when he reached high school age set up a chemistry laboratory in an empty room of his parents' house where he carried out experiments of his own devising. He longed to study medicine, but any hopes that he might have had of realizing that dream vanished when, in 1893, his father died from the effects of an accident, a year after David's graduation from high school. That year he had spent as a clerk in a drugstore, earning what money he could and devoting all his free time to the study of pharmacy, the best substitute he could find for the medical training he so much wanted. Self-taught from the United States Dispensatory except for the practical knowledge he picked up in the drugstore and the bits of information and advice that the general practitioner of Janesville gave him, he prepared himself for the Wisconsin State Examination in Pharmacy and passed with the best record ever previously made.

But before he had practiced long as a licensed pharmacist a way was opened for him to enter a liberal arts college and in 1895, helped by one of his older sisters, he enrolled in Olivet College, Olivet, Michigan. During the five years of his undergraduate studies there he acted as assistant in science; the first year in chemistry and the last four in biology, studying and working under the direction of Hubert Lyman Clark, who later became Curator of Marine Invertebrates in the Museum of Comparative Zoology at Harvard. Professor Clark had but recently taken his doctor's degree at Johns Hopkins University and, when his pupil and assistant had received his B.S. degree with honors at Olivet in 1900, Clark encouraged him to enter the Johns Hopkins graduate school and also helped him to secure an assistantship there, a post which he entered upon in the autumn of 1900.

At Johns Hopkins, David Tennent was one of the group of keen and alert young men who came under the rigorous mental discipline and stimulating influences of Professors William Keith Brooks and Ethan Allen Andrews. As students, they were expected to meet the highest standards of intellectual achievement and their interests were roused in every aspect of biological knowledge and inquiry; as assistants, they were expected to fulfill their duties with accuracy and dispatch. In recalling these student days with those who had shared them with him, Dr. Tennent would often chuckle over the devices which they used and the extent to which they went to collect the material Professor Brooks wanted for his classes. If Professor Brooks gave instructions that certain specimens were to be ready at a stated hour in the morning, they had to be ready and in good condition at that moment, even if the orders meant that his assistants spend the night scurrying through the city of Baltimore and its outskirts, searching ponds and streams, rain-water barrels and water butts for the particular kind of alga or rotifer demanded, with complete disregard for weather, property rights and time but that of the hour when the specimens must be on hand in the professor's laboratory.

The summers of those student years were spent at the Fisheries Laboratory, Beaufort, North Carolina, where with others of the Johns Hopkins group, David Tennent studied the marine flora and fauna of that strip of the Atlantic coast, collected, fished, swam and sailed by day, and by night sat on the broad porch of the laboratory building, looking out over the sea and discussing topics that ranged from practical and theoretical biology to politics, sociology, philosophy and religion. He took one year from his graduate work to substitute at Randolph Macon College, where he was appointed Acting Professor of Biology and Physics. In 1904, he received the degree of Doctor of Philosophy from Johns Hopkins, having held the honored Bruce Fellowship there and been elected to Phi Beta Kappa in his last student year. His doctoral dissertation was "A Study of the Life-History of Bucephalus haimeanus: A parasite of the oyster."

In the autumn of 1904, with his new degree and the stimulus of his Hopkins' days fresh upon him, he began his first term of appointment at Bryn Mawr College. First as an Instructor, then as Associate, Associate Professor, and Professor, he taught there for thirty-four years. There he met, and in 1909 married, Esther Margaret Maddux, and together they set up their home in the village of Bryn Mawr and became as much a part of the community in which they lived as they were of the college where he taught and where she had been a student. Their only child, David Maddux Tennent, now a research biochemist, was born in 1914. Although Dr. Tennent held continuous appointment to the faculty of Bryn Mawr College from 1904 to 1941, his teaching and research were by no means confined to its classrooms and laboratories. The summer of 1909 was the first of many that he spent at the Biological Laboratory of the Carnegie Institution in the dry Tortugas of which Dr. Alfred G. Mayor was founder and director from 1904 until his death in 1922. Dr. Tennent was Executive Officer of this laboratory from 1937 until it closed in 1940. In 1911 he worked at the temporary station established by the Carnegie Institution at Montego Bay, Jamaica, B.W.I.; he worked, too, at various times at the Zoological Station in Naples, Italy, the Hopkins Marine Station at Pacific Grove, California, and the laboratory of the Carnegie Institution at Cold Spring Harbor, Long Island. He spent several summers at the Marine Biological Laboratory at Woods Hole, Massachusetts, where from 1920 until 1923 he directed the course in embryology. In 1913, on special leave of absence from Bryn Mawr, he went to Torres Strait and Thursday Island in the South Pacific as a member of an expedition of the Carnegie Institution of Washington under the direction of Alfred G. Mayor; his former professor, Hubert Lyman Clark, was also one of its members. In 1922-23, on sabbatical leave, he went to the Imperial University of Tokyo's Laboratory at Misaki, Japan, and his last leave, in 1930-31, was spent as visiting professor at Keio University in Tokyo.

The first visit to Japan was marked by tragedy. Toward the end of the summer of 1923 he, his wife and son went to China for a brief holiday before returning home. Always a cautious man, Dr. Tennent took care to leave his scientific equipment, the material he had collected and most of his notes secure, as he thought, in the vaults of a Tokyo bank. On the way back to Japan, their ship received the news of the earthquake that on September first had shaken Tokyo and Yokohama. The bank building, together with his material, was destroyed, and though he later published some of the results of this year's work from the fragmentary notes he had kept with him, its full value was never realized and his disappointment over the loss was never mitigated. This experience left its mark upon him and made him even more cautious than before. For years afterwards he kept his brief case with his current notes and papers always with him, leaving nothing that could not be duplicated or replaced in the laboratory over night, or even during his absence by day unless put in charge of someone to rescue it in case of accident.

All the influences of his student days had conspired to make him a marine biologist, and the eagerness with which he embraced pure science, once the opportunity was given him, and turned to the study of animals of the seacoast for the solution of fundamental problems of biology belies his own admission of regret for the medical career denied him. To many his name is associated especially with the development and structural characteristics of the echinoderms, for they, particularly the sea urchins, provided the material used most extensively in his studies. But the processes that he investigated in them were ones whose interpretation had implications and applications far beyond the confines of any particular phylum. His early work was concerned primarily with the role of the nucleus in differentiation and development, a problem that he approached through a study of hybrids obtained by cross-fertilizations of different species, different genera, different orders and even different classes. These studies on echinoderm hybridization, which are accepted as biological classics, led him, in the logical sequence that he valued so much, to those on the fertilization process and so to investigations of the nature of the cell membrane, the potentialities of egg fragments, the morphological and biochemical organization of the echinoderm egg, and, finally, to the studies of photosensitization upon which he was engaged at the time of his death.

When David Tennent finished his graduate studies and began his own independent investigation, the mendelian theory of inheritance was new, and the chromosomal mechanism of mendelism was just coming into prominence; the contributions of the egg and the sperm to the establishment of the characters of the embryo and the relative roles of nucleus and cytoplasm in differentiation and development were problems in the forefront of biological inquiry. Tennent's visits to marine laboratories in many parts of the world gave him opportunity to determine the chromosomal complement and to study the normal development of many different species of sea urchins. It was this familiarity with the conditions of their development in nature and under standardized conditions in the laboratory that enabled him to establish definite, objective criteria for variations in the hybrids he obtained and to determine the fate of individual chromosomes in the hybrid nucleus. By careful studies of the number of chromosomes and their configurations at anaphase, carried on by himself and his students, he distinguished the autosomes and sex chromosomes of a number of different species, and established the fact that the male is the digametic sex in sea urchins. Thus, when he fertilized the eggs of Toxopneustes (Lytechinus), in which the X chromosome is V-shaped, with sperm of Hipponoë (Tripneustes) in which it is J-shaped, approximately ½ the fertilized eggs contained the J-shaped element and ½ lacked it. Since the J-shaped chromosome was peculiar to Hipponoë and never found in species-fertilized Toxopneustes eggs, it could only have been introduced into the hybrid by the Hipponoë sperm. Since it was found in only 50% of the fertilized eggs, it must have been absent in 50% of the sperm used in the hybridization experiment, thus proving that the male was digametic.

Much of his early work was concerned with the relative contribution of the egg and the sperm in the determination of embryonic and larval characters, for to him "one of the most interesting and important problems connected with the results of Echinoderm hybridization is the determination of the factors influencing the appearance of maternal or of paternal characteristics in the hybrid embryo" (1910). For example, fertilization of the eggs of a Mediterranean species of Sphaerechinus, that produces functional gametes throughout the year, with sperm from Strongylocentrotus, if made in May, June or July, gave larvae of the Sphaerechinus type, while the same cross made later in the year yielded larvae resembling Strongylocentrotus, the sperm-contributing parent. The dominance of one parent over the other was in these crosses determined by the characteristics of the larval skeleton, a feature which he had accepted as the most constant after a detailed study and statistical analysis of the variations ordinarily occurring in larvae from species-fertilized eggs raised under carefully standardized laboratory conditions. Tennent found in Hipponoë-Toxopneustes crosses, that in ordinary sea water, or sea water made slightly alkaline, the larvae of reciprocal crosses were of the Hipponoë type, while in sea water in which the H^+ concentration was increased by the addition of HCl or acetic acid the larvae were of the Toxopneustes type. He suggested that the seasonal variations in the larvae obtained by other workers might be the result of naturally occurring changes in the H^+ concentration of the environment of the parents and of the cleaving eggs from which the larvae were derived. His emphasis at that time on the importance of extrinsic influences upon the development of the individual and of an "optimum" for normal developmental processes has received ample support from more recent genetic and embryological studies.

On the premise that sperms differ in the degree of their effect upon the egg, and that the activating potency of a sperm could be supplemented by "increasing or diminishing its task," Tennent experimented with the effect of exposing eggs before cross-fertilization to monovalent cations, presumed to increase the permeability of protoplasm to water and ions, and to bivalent and trivalent cations, presumed to decrease its permeability. Using in one set of experiments sea urchins of different families (Heliocidaris and Temnopleurus) and in another those of different orders (Heliocidaris and Astriclypeus), he found that after treatment of the Heliocidaris eggs with NaCl, 90% of the eggs inseminated with Temnopleurus sperm formed fertilization membranes and underwent regular cleavage, and that with treatment with $CaCl_2$, $BaCl_2$ or $SrCl_2$, 100% of the Heliocidaris eggs exposed to the sperm of Astriclypeus formed perfect membranes and segmented regularly. His criterion of successful fertilization in these crosses was the elevation of the fertilization membrane and, in those cases in which it could be followed microscopically in the living egg, the union of egg and sperm nuclei. His intention was to check on nuclear fusion in all the inseminated eggs, and so to rule out the possibility of parthenogenesis, but these experiments were carried out at the Misaki Marine Biological Station and the material he had preserved for future study was part of that lost in the Tokyo disaster. Later, similar experiments on the eggs of Tripneustes and Lytechinus confirmed those on Heliocidaris; he found, indeed, that with proper treatment the Lytechinus egg could be brought to a condition in which it was more readily activated by foreign sperm than by that of its own species. These experiments demonstrated the specificity of sperm in the activation of eggs of their own species, a condition which had been accepted but not established; also the difference in degree of their effect upon eggs of other species, and the role of the ionic concentration of sea water in controlling or directing that effect.

Perhaps the most significant of his studies on echinoderm hybridization were those in which he determined the time at which the influence of the paternal chromosomes first manifests itself in the embryo, and those in which he proved that the chromosomes eliminated during the cleavage of cross-fertilized eggs were of paternal origin. By crossing species that differed not only in the tempo of cleavage but in such clear-cut features as the time and site of mesenchyme formation, he was able to produce definitive evidence of the maternal control of early developmental processes and the later effect of the paternal determiners. He fertilized, for example, the eggs of Cidaris, a primitive species in which cleavage is slow and the mesenchyme appears after the formation of the archenteron, with sperm from Lytechinus, a species in which cleavage is completed in about one-third the time of cleavage in Cidaris and the mesenchyme begins to invade the blastocoele at the very onset of gastrulation. These differences between the two species were so evident that there could be no doubt that the cross-fertilized Cidaris eggs segmented at the Cidaris tempo and that the time of appearance and the location of the first mesenchyme cells in the hybrid embryo were Lytechinus in character. Tennent's results were more exact than those of Driesch and others who had studied the same problem but had chosen less well-defined and more variable characteristics, such as larval shape and the total number of mesenchyme cells formed, as criteria of maternal or paternal influence. In these studies, as in those on the elimination of chromosomes from the hybrid nucleus, it was his detailed knowledge of echinoderm cytology that enabled Tennent to answer questions still puzzling others, and to provide definitive proof for certain points about which existing evidence was questionable or conflicting.

Although a number of workers had observed the elimination of chromosomes from the spindles of the early division figures of cross-fertilized eggs, some confusion existed as to the source of the eliminated chromosomes. It was through his knowledge of the details of chromosome configuration in the species crossed that Tennent was able to establish the fact that it was chromosomes of paternal origin, rather than of maternal, that lagged on the spindle and were ultimately eliminated from the hybrid nucleus. In consequence he added another category, "partial hybrids," to the other two, true and false hybrids, proposed in 1918 by Günther Hertwig. Among true hybrids were included all those with complete sets of maternal and paternal chromosomes; among false, those, essentially parthenogenetic in their development, in which the maternal chromosomes alone were retained; Tennent's partial hybrids in which there was a partial elimination of chromosomes of the paternal set might be fertile, sterile, misformed or non-viable individuals. This elimination of chromosomes, and other disturbances of development, apparent in some hybrid embryos, he interpreted as a disorganization of the orderly series of developmental reactions taking place in species-fertilized eggs brought about by the introduction of foreign nuclear material. He therefore proposed that the term "internal block," in current use to designate any check in the series of reactions that make up the fertilization process arising after the successful penetration of the sperm, be restricted to conditions inhibiting the union of the egg and sperm nuclei, and that the term "developmental block" be used for conditions inhibiting normal development after such union. The "developmental block" in hybrids obtained by fertilizing Cidaris eggs with sperm from either

Lytechinus or Tripneustes, an interordinal cross, is apparent in the gastrula stage of the hybrid embryos and represents, according to his interpretation, the expression of divergence of the two paths of development characteristic, on the one hand, of the maternal species and, on the other, of the paternal. Emphasizing again that what is transmitted from parent to offspring is a potentiality of development, rather than fixed and specific characters, he pointed out that this development depends upon reactions between nucleus and cytoplasm, and upon adjustment to environmental conditions. From evidence obtained in crosses between Arbacia and Moira and between Lytechinus and Tripneustes, he concluded that foreign sperm brings about changes in the physical characteristics of the cytoplasm of the egg, possibly due to the action of foreign enzymes on the cytoplasmic substrates. His observations of the appearance and disappearance of basophilic material in the vicinity of the nucleus in the early cleavage stages of Arbacia eggs activated by Moira sperm, and his statements: "there is a distinct impression of diffusion from the nucleus"; and later, "the sections give the impression of a movement of some of the contents of the cell toward the nucleus"; and finally "the nucleus in cross-activated Cidaris eggs seems to be supplied with more material than it can utilize" were perhaps less significant thirty years ago, when he wrote them, than they are today, when so much of the attention of cytologists and cytochemists is focussed on the nucleic acid metabolism of the cell.

His interest in the chemical constitution of the cell was expressed in the analysis made under his direction of the alcohol-soluble components of the eggs of Echinometra lucunter, the reaction of the substances so extracted to standard histological fixation and staining procedures and the comparison of these reactions with those given by components in the cells of ovaries collected at the same time and preserved for cytological study. While this study was in progress, he was collaborating with C. V. Taylor and D. M. Whitaker in an investigation of the morphological organization of the egg of Lytechinus variegatus, and the developmental capacities of egg fragments. The eggs were fragmented by a microdissection technique, which made possible the exact localization of the fragment removed, and subsequently fertilized by sperm of the same or different species. The transparency of these eggs, and an ingenious device of Taylor's, enabled the observers to keep the egg fragments under almost continuous observation and to make accurate records of the larval structures they formed.

It was in the course of these investigations that his attention was directed to the effects of sunlight upon the eggs of Lytechinus stained with neutral red, a dye which, non-toxic to the cells in the dark or in moderate diffuse light, became toxic after exposure to the direct rays of the sun, a change presumably brought about by a compound formed from neutral red by a photochemical reaction. He planned an extensive program of research on the photodynamic effects of a wide range of non-toxic dyes exposed to different intensities of light. This promised to be the most valuable and the most significant of his studies, the culmination of all that he had learned about the cell in growth and division, for he saw in it the possibilities of an interpretation of the complex processes of typical and atypical growth. Although he had assembled the data of a long series of experiments, he died before he had completed his interpretation of them, and it is a loss to biological thought and progress that he had not time to put on paper the conclusions he had drawn from his study, the only record of which is in the memories of those with whom he had discussed them.

His published work is a succinct and critical exposition of his own and contemporary work, the logical development of ideas and evidence substantiating them, and much that is instructive in technique and stimulating to thought. His written words express the qualities of mind that characterized him as an investigator and as a teacher, and the standards and traditions of scientific work that he established for all with whom he came in contact as instructor, collaborator and fellow-worker constitute a great measure of his contribution to the progress of biological science. Professor Robert E. Coker, a friend and scientific companion since the days when they were students together at Johns Hopkins, said of him: "There was almost no waste effort in his research. He always had a significant problem to begin with. A keen mind sensed the opportunity for crucial experiments; driving energy and intensive application carried the research through; comprehensive knowledge and broad vision enabled him to steer away from ready pitfalls: and, finally, a highly discriminating judgment, reinforced by basic integrity, saved him from conclusions that would require later revisions by himself or others." To these characteristics of his research might be added the meticulousness and precision of his techniques, the thoroughness with which he worked at a problem and the pertinacity with which he returned again to points in procedure or in deduction with which he was not wholly satisfied. These were the qualities that made his work so sound and so enduring, but robbed him of the wider fame he might have had, for he chose to answer questions rather than to raise them, and his work is characterized more by its completeness than by controversial issues opened or new lines of thought developed.

That his research was highly valued during his life is attested by the increasing opportunities given him to broaden it and to carry it further afield, and by the scientific honors that came to him. Dr. Tennent was President of the American Society of Zoologists in 1916, and of the American Society of Naturalists in 1937. He was elected to the National Academy of Sciences in 1929 and in 1938 was made a member of the American Philosophical Society. He was an active member of all the organizations to which he belonged, as he was of the faculty in which he held appointment, taking his full share of committee work and performing it with the diligent conscientiousness that was characteristic of all that he did.

His whole life was one of diligence, industry and perseverance. In his research, in his teaching, in his administration, and in his dealings with other people he was a perfectionist. In all that he did he set himself the highest goals and took pride in attaining them. It was his boast that he never came to a decision without ascertaining all the available facts in the case, duly weighing the evidence and finally coming to an impartial and objective judgment. If his deliberation sometimes made those who worked with him impatient, they were bound to respect the honesty and sincerity of his final word. He was a severe critic of his own observations and conclusions, weighing them always in relation to the implications of the work of others, and he adhered strictly to his own exacting standards in research and publication. In the conduct of his life as in that of his experiments he was a scientific realist; he could not go beyond the evidence and once he had drawn his conclusions from it, clung to them with a tenacity that at times bordered on stubbornness.

During his teaching years he trained many undergraduate and graduate students, preparing them for advanced study, for research and for teaching. Twelve students, alumnae of other colleges as well as of Bryn Mawr, completed their work for the doctorate under his direction. To his students he was a kind friend, and in the tradition of his own student days, an exacting instructor. His own standards of intellectual integrity, of industry and accuracy in all that he said and did were so high that he expected the same of others but he never asked more of them than he did of himself. He was impatient with superficiality and intolerant of indolence, but patient beyond most with honest effort, however unsuccessful. He was a man of few words, but those he did speak were apt and well-timed; he knew when to encourage his students, when to ignore and when to chasten them. On the occasions when even his patience was exhausted by the perversity of objects or the carelessness or stupidity of individuals he could give way to bursts of anger so real that those who witnessed it were not apt to forget it nor the incident that had aroused it. Both by precept and example he was a good teacher; anyone who was under his instruction could hardly fail to appreciate and to value the quickness with which he perceived and the clarity with which he presented the essence of a subject, the precision and deftness of his laboratory technique, the comprehension and skill with which he planned a course of action, the patience and persistence with which he followed it, and, above all, the pure delight that he felt in scientific research.

Professor Tennent ended his active teaching at the close of the academic year 1937-38, having reached the age of obligatory retirement. But he felt himself vigorous and alert and far from desirous of abandoning either teaching or research or indulging in the leisure he had so amply earned. He was moreover deep in the study of some of the material that he had prepared during his last summer in the Tortugas which he would have found difficult to continue outside of a laboratory. Fortunately it became possible for the college to offer him a research professorship, and it was as their first research professor that he continued his work. He was in his laboratory throughout the day before his sudden death on January 14, 1941.

In the administration of his department he was fair, wise and far-sighted. To his staff he was generous and just, an ambitious yet provident leader; he defended their rights, shared their personal and professional happiness and disappointments, counselled and encouraged them. If criticism or censure was necessary, he felt it his responsibility to give it, and never evaded what he considered his duty, however unpleasant it might be to him. He insisted that everyone associated with him have time and opportunity for reseach and felt an almost personal gratification in the achievements of his staff. Believing in the unity of science, he emphasized in his teaching and his administration the interrelationship of all the natural sciences and developed in his department the borderline fields of biochemistry and biophysics. It was largely due to his thinking and his efforts that a plan for coordinated teaching in the natural sciences was in 1935 instituted at Bryn Mawr, supported by a fund given by the Carnegie Corporation of New York. Under this plan, students with basic training in two or more of the natural sciences are enabled, as advanced undergraduates or as graduates, to continue their studies under the joint direction of two departments, and to become familiar with the problems and methods and be trained in the techniques of more than one field of specialized knowledge.

He was a valued, respected and much-loved member of the faculty to which he belonged. Bryn Mawr College was but twenty years old when he came to it, and he early identified himself with those on its faculty who worked for liberal policies in teaching and in administration. He was one of a group of faculty members who drew up the "Plan of Government" upon which the college has operated since 1916 and which, based on the principles of democracy, provides for faculty representation on college committees and faculty cooperation in the problems of administration. He himself served faithfully on nearly all the committees that he had helped to set up, giving his time to them fully and efficiently. He was a man in whose kindness, fairness and rightness of opinion every one had trust; though rigid in his beliefs and firm in his convictions, he was able to see both sides of a question and to give dispassionate judgment, even though in his kindness and friendliness he might deplore the decision and secretly suffer because of it. His colleagues and his students had confidence not only in his wisdom but in his fairness. He paid the price of that confidence and trust in the heavy load of committee work that was asked of him both by the college and the organizations to which he belonged, and the frequency with which others turned to him for advice and help when they were in difficulties.

He was no scholarly recluse, shut off from others and the affairs of the world around him. He and his wife delighted in the society of their friends, and their house was a place where many were welcomed with genuine friendliness and warm-heartedness. Though he was formal in his manner and gave the impression of shyness, he was a gracious host and took evident and genuine pleasure in providing his guests with the best that he could offer, whether of food or drink or entertainment. He followed with enthusiasm the course of his son through school and college, sharing with him the excitement of football and baseball games, plays and dances. He regretted the increasing informality of daily life and was always most punctilious in his social relations; he confessed that one thing that pleased him about his appointment to Keio University in 1930 was that he would once again have the opportunity to wear a top hat as a matter of course on appropriate occasions. He was good company, for he was an excellent raconteur, with a fund of stories, some of them of his student days, some of them of his adventures in the many places where his work or his pleasure took him, and some of them garnered from his wide and cosmopolitan circle of friends. He loved to share a good story as he loved to share a good book or an experience that he had found especially interesting or otherwise satisfying. Few of those who knew him well and heard him tell of his experience in the South Pacific can see a picture of the Great Barrier Reef without projecting into it an image of his short and rather stocky figure, intent upon the observation of the sea creatures living there whose form and origin and behavior fascinated and puzzled and charmed him. But besides vividness, his stories had spice and humor; often beginning them with a shy and tentative smile, he would end them shaking with the laughter that he would have restrained if he could.

He was as much a figure and influence in the community where he lived as he was in the college where he taught. His advice was sought on local affairs and he always had time to give it judicially, as he always had time to chat for a minute or two, on his way back and forth between his home and the college, with his friends at the bank, the lumber mill and the drugstore. There were often fishing parties with this circle of friends as well as expeditions to the Philadelphia baseball parks where the fortunes of the American and National League teams were followed with keen interest and obvious enjoyment. Later, he began to play golf and in the last years of his life nearly every Sunday morning saw him on the links, even in weather which defied younger and more vigorous men.

He was loved, he was respected, he was honored, and his life was full of the satisfactions that come from the knowledge of work well done and of purpose achieved. He never failed to have a kind of boyish pleasure in gaining an objective he had decided upon and a genuine intellectual satisfaction in seeing a carefully thought out plan gradually unfold itself to the end he had intended. Though he was a modest man, he did not underestimate the standard of values he had set for himself or his own accomplishments. And he was fortunate in knowing during his life, from the tributes that were paid him, the affection and esteem in which he was held by others and the respect he had inspired as a man and a scientist. He had all the qualities that make the scientist,—the driving curiosity about objects and events in the natural world, the urge to experiment with them, the complete integrity and critical objectivity that scientific analysis demands; but he also had, in greater measure than most, those other attributes that mark the best among men and the best among scientists—simplicity before men and humility before God. His death was a sad loss to the college that he served and to the science that he loved.

BIBLIOGRAPHY

KEY TO ABBREVIATIONS

Amer. Nat. = American Naturalist.
Arch. Entw.-Mech. = Archiv für Entwicklungsmechanik der Organismen.
Biol. Bull. = Biological Bulletin.
Carnegie I.W. Publ. = Carnegie Institution of Washington, Publications. Tortugas Laboratory.
Carnegie I.W. Yr. Book. = Carnegie Institution of Washington, Year Book. Tortugas Laboratory.
J. Exp. Zoöl. = Journal of Experimental Zoölogy.
J. Morphol. = Journal of Morphology.
Proc. Nat. Acad. Sci. = Proceedings, National Academy of Sciences.
Proc. 7th Int. Zoöl. Cong. = Proceedings, Seventh International Zoölogical Congress.
Q. J. Micros. Sci.= Quarterly Journal of Microscopical Science.

1906

(With M. J. Hogue.) Studies on the development of the starfish egg. J. Exp. Zoöl., III, no. 4, pp. 517-541, 5 pl.

A study of the life-history of Bucephalus haimeanus; a parasite of the oyster. Q. J. Micros. Sci., XLIX, pt. 4, pp. 635-690, pl. 39-42.

1907

Further studies on the parthenogenetic development of the starfish egg. Biol. Bull., XIII, no. 6, pp. 309-316, 14 figs.

Hybrid echinoderm larvae. Proc. 7th Int. Zoöl. Cong., pp. 519-520.

1908

The chromosomes in cross-fertilized echinoid eggs. Biol. Bull., XV, no. 3, pp. 127-134, 1 pl., 12 figs.

1909

An account of experiments for determining the complete life-history of Gasterostomum gracilescens. Science, n.s., XXIX, no. 741, pp. 432-433.

Experiments in echinoderm hybridization. Carnegie I.W. Yr. Book, no. 8, pp. 136-138.

1910

(With V. H. Keiller.) The anatomy of Pentaceros reticulatus. Carnegie I.W. Publ., no. 132, pp. 111-116, 3 pl., 2 text cuts.

The dominance of maternal or of paternal characters in echinoderm hybrids. Arch. Entw.-Mech., XXIX, 1, pp. 1-14, 2 figs.

Echinoderm hybridization. Carnegie I.W. Publ., no. 132, pp. 117-151, 6 pl., 7 text cuts.

Experiments in echinoderm hybridization. Carnegie I.W. Yr. Book, no. 9, pp. 134-135.

Variation in Echinoid plutei; a study of variation under laboratory conditions. J. Exp. Zoöl., IX, no. 4, pp. 657-714, 21 figs.

1911

A heterochromosome of male origin in Echinoids. Biol. Bull., XXI, no. 3, pp. 152-154, 3 figs.

1912

The behavior of the chromosomes in cross-fertilized echinoid eggs. J. Morphol., XXIII, no. 1, pp. 17-25, 2 pl.

The correlation between chromosomes and particular characters in hybrid echinoid larvae. Amer. Nat., XLVI, pp. 68-75.

Investigations on the hybridization of Echinoids. Carnegie I.W. Yr. Book, no. 11, pp. 152-153.

Studies in Cytology: I. A further study of the chromosomes of Toxopneustes variegatus; II. The behavior of the chromosomes in Arbacia-Toxopneustes crosses. J. Exp. Zoöl., XII, no. 3, pp. 391-405, 3 pl., 21 figs.

1913

Echinoderm hybridization. Science, n.s., XXXVII, no. 953, pp. 535-537.

1914

The early influence of the spermatozoön upon the characters of echinoid larvae. Carnegie I.W. Publ., no. 182, pp. 127-138, 11 text-figs.

1920

Evidence on the nature of nuclear activity. Proc. Nat. Acad. Sci., VI, no. 4, pp. 217-221.

1922

Studies of the hybridization of Echinoids, Cidaris tribuloides. Carnegie I. W. Publ., no. 312, pp. 1-42, 3 pl., 28 figs.

1924

Investigations on the hybridization of Echinoids conducted at the Misaki Marine Biological Station of Tokyo Imperial University, from April 24 to August 16, 1923. Carnegie I. W. Yr. Book., no. 22, pp. 169-171.

(With C. V. Taylor.) Preliminary report on the development of egg fragments. Carnegie I. W. Yr. Book, no. 23, pp. 201-206.

Specificity in fertilization. Science, n.s., LX, no. 1546, pp. 162-164.

1925

Investigations on specificity of fertilization. Carnegie I. W. Yr. Book, no. 24, pp. 240-242.

1926

(With C. V. Taylor and D. M. Whitaker.) Investigation on organization of echinoderm egg. Carnegie I. W. Yr. Book, no. 25, pp. 249-255.

1928

Microscopic investigation of the fixing and staining reactions of substances extracted from the eggs of Echinometra lucunter. Carnegie I. W. Yr. Book, no. 27, pp. 339-351.

1929

Activation of the eggs of Echinometra mathaei by sperms of the crinoids Comatula pectinata and Comatula purpurea. Carnegie I. W. Publ., no. 391, pp. 105-114, 5 text-figs.

Early development and larval forms of three Echinoids of the Torres Strait Region. Carnegie I. W. Publ., no. 391, pp. 115-118, 15 text-figs.

(With C. V. Taylor and D. M. Whitaker.) An investigation on organization in a sea-urchin egg. Carnegie I. W. Publ., no. 391, pp. 1-104, 59 text-figs.

1931

(With M. S. Gardiner and D. E. Smith.) A cytological and biochemical study of the ovaries of the sea-urchin Echinometra lucunter. Carnegie I. W. Publ., no. 413, pp. 1-46, 7 pl.

1933

Experimental studies in the embryology of Echinoids, particularly Clypeaster rosaceus. Carnegie I. W. Yr. Book, no. 32, p. 265.

1935

Investigations on the photodynamic properties of vital dyes. Carnegie I. W. Yr. Book, no. 34, pp. 91-92.

The photodynamic effects of vital dyes on fertilized sea-urchin eggs. Science, n.s., LXXXII, no. 2139, p. 621.

1936

The effect of irradiation of eggs of Lytechinus with sunlight during development in various dyes. Carnegie I. W. Yr. Book, no. 35, pp. 93-96.

1937

The effect of irradiation of Lytechinus eggs in various dyes with sunlight. Carnegie I. W. Yr. Book, no. 36, pp. 106-107.

1938

The effect of intensity of light on photodynamic reactions. Carnegie I. W. Yr. Book, no. 37, pp. 102-103.

Some problems in the study of photosensitization. Amer. Nat., LXXII, pp. 97-109.

1939

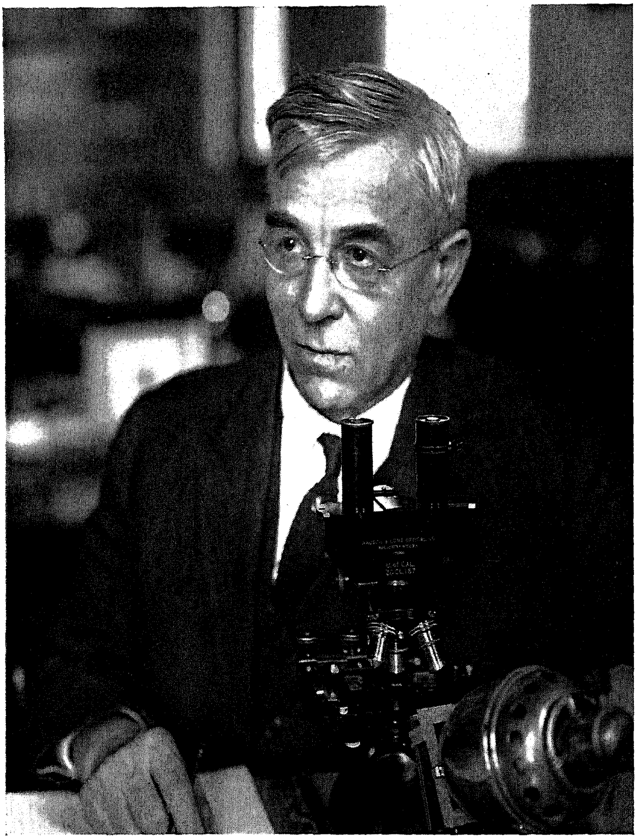
The photodynamic effect of dyes on the eggs of Lytechinus variegatus. Carnegie I. W. Yr. Book, no. 38, pp. 231-233.

1941

(With Toshio Ito.) A study of the oögenesis of Mespilia globulus (Linné). J. Morphol., LXIX, no. 2, pp. 347-404, 12 pl.

1942

The photodynamic action of dyes on the eggs of the sea-urchin, Lytechinus variegatus. Carnegie I. W. Publ., no. 539, pp. 1-153, 8 pl., 40 text-figs.



Charles Atwood Kofoid

CHARLES ATWOOD KOFOID[1]

1865–1947

BY RICHARD B. GOLDSCHMIDT

Charles Atwood Kofoid was born on a farm near Granville, Illinois, on October 11, 1865. His father, Nelson Kofoid, had immigrated from Bornholm, Denmark, five years earlier and had settled as a cabinetmaker and contractor in that little midwestern town. Kofoid himself referred frequently with pride to his Scandinavian descent, kept up correspondence with his Danish relatives and also visited them. His mother, née Janette Blake, was of old Puritan stock, descendant of one of the early Massachusetts settlers, William Blake. Although nothing is known of the parents' influence upon the boy, the Puritan background remained rather conspicuous throughout his life. No information has come down concerning his boyhood and early education, but the fact that he entered Oberlin College when he was already 21 years of age and worked his way by waiting on tables and sawing wood indicates that he had not had an easy time before he was able to begin his college education. It seems that his interest in biology was awakened at Oberlin by Professor Albert Wright, who inspired him with the beauties of the living world. He started collecting plants and making field trips, and he had his first taste of teaching in his junior year as an assistant in zoology.

While in college he became engaged to Carrie Prudence, the daughter of the Rev. Alpheus Winter, soon to become Mrs. Kofoid. She was his almost lifelong companion and had an immense influence upon his extra-curricular activities as well as his mode of life and thinking.

After his graduation in 1890, he served for a year as teaching fellow at Oberlin and afterwards went to Harvard for three years of graduate study under Professor Mark. His fianceé taught girls in Middletown, Connecticut, until their marriage on June 30, 1894. His doctor's thesis dealt with cell lineage, a topic in embryology, which had become popular through Whitman's work. His material was Limax, and the paper is a creditable contribution although Kofoid never returned to this field. After receiving his degree, Kofoid obtained a position in Illinois. His principal work there was with a natural history survey of the Illinois River, and he was permitted to call himself the director of a floating laboratory. Simultaneously he taught at the University of Illinois. It was during the six years which he spent in this survey that his interest in the plankton organisms was developed and, still more important for his future work, the happy association with Jennings aroused an interest in the protozoa, a group to which most of his life work was to be dedicated.

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[1] The following biographical accounts were available to the writer:
A. E. Noble. Bios, 6, 1935: 243-249.
C. Dobell. Nature, 160, 1947: 115.
H. Kirby. Univ. Calif. Fac. Bull. 17, 1948: 80-82.
——— Science, 106, 1947: 462-463.
——— Sci. Mo. 61, 1945: 415-418.
——— Anat. Rec. 101, 1948: 403.
Professor Harold Kirby kindly offered the writer the use of his extensive notes and contributed the bibliography assembled by the University of California Library. Without this gratefully acknowledged help this memoir could not have been finished.

In Harvard he had met William Emerson Ritter, who wanted to take him to California. But President Eliot forced him to keep the appointment in Illinois, which he had aided him in securing. When Ritter renewed his offer it was not difficult to entice Kofoid to come to the University of California as an assistant professor, though on a very small salary. Ritter was at that time occupied in modernizing the teaching of zoology in this University. In addition he was about to found a marine biological laboratory and Kofoid, with his abundance of energy, seemed to be the proper collaborator. Kofoid remained Ritter's friend to the end of the senior zoologist's long life. Kofoid remained in Berkeley from 1903 to 1936, and after his retirement in 1936 until his death. According to Ritter's plan, Kofoid had a great share in selecting the site and starting a zoological station at San Diego and later at La Jolla, the present Scripps Institution of Oceanography. From 1907 to 1910 he served as assistant director of the San Diego station and from 1910 to 1923 as assistant director of the La Jolla station. Meanwhile, in 1904, he had been promoted to associate professor and in 1910 he became Professor of Zoology and Chairman of the Department. He held this position until the time of his retirement, except for four years when there was a rotating Chairmanship.

When the aging Alexander Agassiz made his *Albatross* expedition to the South Seas in 1904 and 1905, Kofoid participated as planktonologist and collected a huge amount of material. This expedition played a great role in his recollections, and in his later days he loved to tell especially of his visit to mysterious Easter Island. This was his first real travel, and it whetted his appetite for more, so that whenever there was a chance he went abroad. In 1908 and 1909 he was in Europe working part of the time at the famous Naples Zoological Station and part in the monastic halls of the Zoological Institute in Munich, where the present writer first saw a good deal of him. In 1916 he made a collecting trip to India, and one of his favorite stories later was how he shot an elephant in order to collect its parasites. In 1920 he made another trip to Europe, and in 1930 he accepted for a year the visiting professorship which the Rockefeller Foundation had endowed at the Tohoku Imperial University in Sendai. This trip he enjoyed more than all others, and he loved in his later years to talk privately or publicly about Japan, although his picture was somewhat obscured by too much association with Japanese in the missionary circles. His last major trip was a European tour after his retirement. The last ten years of his life were spent in Berkeley, mostly with his hobby of book collecting, and science did not attract him very much any longer. He died from a heart attack on May 30, 1947, after a month in a hospital.

An evaluation of Kofoid's performance and personality must begin with mention of his unbelievable power for work and activity. He was not the type of scholar who shuts himself in an ivory tower. His intensive and extensive temperament did not permit him to be satisfied with patient search into a problem with all the detours, failures, and disappointments contingent upon a quest into the inside of things. Neither did he have the patience to start experimental work, which absorbs all the time and energy of the investigator. He had to have things done, and the more of them the better. This basic pattern of his mind, combined with a strong collector's instinct, determined the type of his work. His actual research work was only one facet of the many surfaces of his activity, in spite of the fact that the printed output was an immense one. This was made possible in part by the nature of his work which, being very much of the cataloguing type, permitted the extensive use of collaborators and paid assistants, at least in his later years, and lent itself to efficient organization by an administrative mind. For this reason it is not easy to describe the actual accomplishments of his research work, most of which was not a search for answers to important problems but was stimulated by the wish to extend the knowledge of living forms in their most detailed aspect. After he had become interested, in his younger days, both in plankton organisms and in protozoa, he spent much effort upon a systematic study of planktonic protozoa. He had made large collections during the Agassiz expedition and later, in his association with the new biological station on the California coast, he had a chance to collect on a large scale. With his usual resourcefulness he constructed two excellent pieces of collecting apparatus which bear his name: the Kofoid horizontal net, which can be opened and closed at will in the desired depth, and the Kofoid self-closing bucket for vertical plankton studies. His systematic work on two of the main groups of plankton protozoa, the tintinnoids and the dinoflagellates, extended over many years, and some of his collections were worked out by others almost a lifetime after they had been made. His results were presented in numerous individual papers and a series of large, expensively illustrated monographs. They have been criticized abroad because he belonged to the group of "splitters," who tend to describe all small deviations from type as new species. But they certainly catalogued and illustrated an immense amount of material for those who might become interested in these groups.

Though less voluminous and conspicuous, his numerous contributions to the knowledge of individual forms of protozoa seem to be more important than the large monographs, and established him as an excellent protozoologist. He had an ability to pick out interesting forms and to describe them thoroughly. I think, for example, of the cystoflagellate *Craspedotella,* which suggests the morphological features of a Medusa. To this group of papers belong also some which go beyond systematic and morphological description, such as his work on exuviation and regeneration in dinoflagellates and his interpretation of the structure of *Noctiluca.* But his most important contributions to the morphology of the protozoa were made during his association with Olive Swezy. Many co-authored papers dealt with the mitosis of flagellates and amoebae. The most interesting work of this period relates to the complicated structure of the parasitic protozoa of termites and to the remarkable system of fibrillae in different groups of protozoa, which can be made visible by silver impregnation and which was interpreted as a neuromotor system. Much of the important work in this field (the original discovery is due to Neresheimer) has been carried out by Kofoid's students, and the writer is inclined to consider this as Kofoid's most important contribution to protozoology.

The second line of research, to which Kofoid devoted many years of his youth, was quantitative and statistical plankton work. In his position as superintendent of the Illinois River work the collection of statistical data on plankton distribution and movement, which is of basic importance for fisheries, was his major duty: certainly a tedious duty, with not many rewards in the form of major discoveries in sight. He did not finish his reports on this work until after he had gone to California. In 1903 the first part of the results was published in a volume of forbidding size, which contains the description of the environment and the volumetric investigations. A second big volume, which appeared in 1908, contains the tabulations of 235 collections made over 5 years. After his removal to California his interest shifted from fresh-water to marine plankton, but purely quantitative studies were given up and replaced by the study of the protozoa in the plankton.

The third major line of Kofoid's work was suggested to him by external circumstances. He had already become interested in some groups of intestinal protozoa, those living in the intestines of termites, ruminants, and the elephant,—protozoa of various groups known for their weird forms and complicated structure. In 1918 he was appointed a Major in the U. S. Army Sanitary Corps, to make a hookworm survey and later to organize a parasitological laboratory. The task appealed to him not only for patriotic reasons but also as a chance to practice his organizing abilities and to do research on human parasites, especially *Endamoeba histolytica*, the cause of amoebic dysentery. With his usual vigor he attacked the problems of morphology and taxonomy of this parasite and published many papers on his findings. He described a new genus and several new species of Amoebae in man. The "splitter" in his nature as a taxonomist had been awakened. Protozoologists did not take very kindly to this work, considering it to be mistaken interpretation of observed variation. After his army service, he and his students returned repeatedly to work in parasitology, including also parasitic worms. Much of this work was of the statistical, collecting type to which his nature inclined.

Kofoid's wartime work led to what was probably the most unpleasant experience of his life, of which in later years he never talked. A rich Indian Parsee, Mr. Tata, had endowed a professorship of protozoology in the School of Tropical Medicine in Bombay, and the Committee on Tropical Diseases of the Royal Society was to make the selection. Kofoid applied for this position, although it was stipulated that graduate teaching, not research, should be in the foreground. He felt attracted, according to his own statement, by the possibility of a cooperative effort in preventive medicine between public health enterprises and philanthropic and industrial organizations; and further, by the idea of starting a research library and a research journal, the possibility of erecting a museum of preventive medicine, and graduate teaching in protozoology in the interest of Indian physicians. Thus it seems that the organizer and the philanthropist in him were behind the astonishing decision to leave California for India. As he had asked that his library should be purchased by the Bombay Institute, he was clearly inclined to leave for good. The Royal Society presented his candidacy to the Bombay school and, soon after, he received his appointment to the chair with the huge salary of 36,000 rupees. At that time an English protozoologist, known for his aggressive criticism, violently attacked Kofoid's war work in the Tropical Diseases Bulletin, and Kofoid was disturbed lest this should undermine his position in India. The problem was solved for him when the institute did not materialize.

As indicated above, Kofoid's research work in protozoology and parasitology was only a small part of his vast activities and not even the part which gave him most satisfaction. One of his most prominent traits was his civic conscience, the sense of duty toward the commonwealth, which included the University, the public, the teaching profession, and the public health organization. Thus a large share of his efforts went into the application of his biological knowledge to the common good. This was done within the University as well as outside, and the many phases of these activities were more instrumental in securing him his prominent position in the University and in the profession than was his actual research work. These activities, any one of which would have taxed the working ability of any other man, were too numerous to be reported in toto, and only the most important ones will be considered. The early association with Professor Ritter and his plans for a Pacific Coast Biological Station aroused Kofoid's interest in marine laboratories. He spent considerable time in exploring the different possibilities along the California coast and when first the San Diego, later the La Jolla site were chosen, he devoted his energy to equipping and planning the work and organization of the station and its integration into the University program. Afterwards, when his work was concentrated on the Berkeley campus, he retained his deep interest in marine laboratories. When he went abroad in 1909 to work at the Naples Station, he accepted an invitation of the U. S. Bureau of Education to report in detail on the work of European stations. The result was a book giving a full and well illustrated account of the biological stations, their work, equipment, and history.

A major effort of Kofoid's went into organization of work on human parasites in the interest of public health. After his return from the Army he took over the direction of the parasitological work of the Bureau of Communicable Diseases, California State Board of Health. He organized a laboratory for parasitological examinations, which he conducted until after his retirement. According to Kirby, "An important feature of his laboratory was the technical training of students working in it, and the upholding of standards of accuracy and thoroughness that had a valuable influence upon the training of medical technicians in the state."

Another time-consuming project in the public interest came up when in 1914 marine borers (the shipworm, *Teredo*) appeared in the Navy docks of Mare Island, San Francisco Bay. During the following years the damage spread over all the waterfront installations in the northern part of the Bay. They had been built with untreated wood because it was supposed that the fresh water of the Sacramento River would protect the wood. In 1920, when the damage had become very severe, a committee was organized with the interest of the American Wood-Preservers' Association and the Forest Products Laboratory, and Kofoid became chairman of the Sub-Committee on Biological Research. This assignment was "to study the present distribution of marine borers, their past history, dissemination, growth and habits, and the factors that influence their rate of attack and the resulting damage." Together with a group of his students, Kofoid started this work. Later it was realized that a larger framework was needed, and a Committee on Marine Piling Investigation was initiated by the National Research Council. The San Francisco committee became the Pacific representative of this group, and tested wood samples from various Pacific stations. The final report of the investigations, edited by Hill and Kofoid, appeared in 1927 as a lavishly illustrated and documented volume.

This work led to another of still larger scope. It originated with the discovery of *Coptotermes* in the wood of an ocean liner, suggesting the possibility of introduction of this devastating pest into the already termite-infested State of California. Therefore a committee on termite damage was organized, in which Kofoid participated prominently, together with the late S. F. Light. All phases of the life history and activities of termites in California were studied. Although in this case Light and the students did most of the actual biological work, as R. C. Miller had done in the *Teredo* investigations, it was Kofoid's enthusiasm, public spirit and unrelenting drive which led up to the results published in 1934 as a big volume on Termites and Termite Control.

These are some of the major activities of Kofoid in fields of applied zoology. There were many minor ones, such as his special investigations for the U. S. Bureau of Fisheries into the pearl fisheries of India and the cultured-pearl industry of Japan.

All these manifold, time-and-energy-consuming activities were carried out while Kofoid, as Professor of Zoology and Chairman of the Department, did the usual University work, which he took very seriously. He had come to Berkeley originally as assistant professor of histology and embryology, to join a staff which had been reorganized by Ritter for the modern laboratory type of teaching and which had already included such men as H. B. Torrey, S. J. Holmes and J. C. Merriam. He taught in these years embryology, cytology, and general zoology and did his share in the instruction in marine biology. When Ritter began to spend most of his time at La Jolla, and later left the Berkeley campus, Kofoid took over the direction of all zoological work, especially after he became Chairman in 1910. He left his former classes to others and introduced courses in protozoology and parasitology, and laboratory and seminar work in this field. But occasionally he liked to give the introductory course in zoology, and in later years one of his hobbies was the organization of a class in the history of biology.

Kofoid took his teaching as seriously as everything else, insisting upon exactness, detailed and complete knowledge, and high standards. But it would be wrong to say that he was an inspiring teacher in class, as he was a rather dry lecturer. He was very different in seminars or scientific lectures, where his clarity of mind and logical presentation showed what he could do as a lecturer. In his Department he concentrated his interest upon his graduate students, about 60 of whom took the doctor's degree under him. A considerable number of his papers were prepared in collaboration with these students, who had to work hard and were pushed relentlessly by their exacting teacher. Among those who succeeded later in the learned profession are Edward Hindle, Olive Swezy, C. V. Taylor, R. C. Miller, G. H. Ball, E. G. Moberg, A. S. Campbell, Harold Kirby, S. F. Light, J. McA. Kater, A. E. Noble, E. H. Myers, and E. R. Noble.

As Chairman of the Department of Zoology for most of 26 years Kofoid strove to organize teaching in zoology in all its phases and aspects, setting very high standards of perfection. It is certain that he succeeded in making the Department one of the best organized teaching teams in the country. It is also true that this was not accomplished without damage to the other members of the Department. Just as Kofoid drove himself relentlessly, so he drove others. He was full of new plans which had to be executed at once. He also had the old-fashioned, actually European, idea that the Chairman is the Department and therefore considered all funds and assistance as belonging only to his work, which caused much unhappiness among the other professors. There was certainly no ill will in all this; it was the outflow of his powerful, even a little tyrannic, personality and his inexhaustible drive to go ahead at maximum speed. If he wanted to get things done he took it for granted that everybody had to pull to exhaustion, although this word was not in his own vocabulary.

On top of all this activity Kofoid was able to do a considerable amount of work at the periphery of science. He was an editor or associate editor of a number of periodicals. The University of California Publications in Zoology were edited by him for many years and he did this work with the same accuracy and care for the minutest details as was conspicuous in all his other activities. Being very much interested in the cataloguing type of work, he wrote innumerable abstracts and reviews, probably thousands, on all phases of his fields of interest, including the history of biology. He was always ready to give University Extension lectures in every part of California, to speak to societies and clubs on topics of general interest, to give interviews, and to serve on civic, scientific or university committees.

How he could manage, in addition to all this, to indulge in a time-consuming hobby is hard to understand. Kofoid was an enthusiastic collector of books, especially those bearing on the history of biology. One never passed the door of his office without finding it blocked by newly arrived packages. The correspondence with book dealers and the study of catalogues must have consumed hours every day. He bought rather indiscriminately, in large lots, then picked out what he wanted and resold the rest. After his retirement he devoted practically all his time to this hobby and even kept an employee of the Department occupied in handling all this traffic. There were books in his office, in his home, in his garage, and in large rooms provided by the University Library. At the time of his death his collection, which he left to the University, contained more than 40,000 volumes not then present in the University Library, among them many first editions, complete sets of editions, and rarities. He left also a collection of about 120,000 reprints. The astonishing thing is that he actually knew his books, their relative importance and history, and he knew exactly what he had and could find any volume at once. He greatly cherished in this collection the esthetic side, also, the good illustrations, printing, and binding, and he probably got more pleasure out of this hobby than out of any of his other activities.

Finally his extramural activities were as extensive and intensive as all his real work. He probably spent very little time on so-called pleasures, except hiking, driving and traveling, but he was very active in civic and philanthropic affairs. In this domain he was mainly the collaborator and helper of his wife who, childless, was untiring in social work, church work and women's club work. Kofoid spent many evenings on church affairs, and was an important and active member of the First Congregational Church. He even went as delegate to church and missionary congresses and associated a good deal with men of this profession. Thus it is not surprising that he left his considerable estate half to the University and half to the Pacific School of Religion, which just now is building a "Kofoid Hall."

An appraisal of Charles A. Kofoid as a scientist must honestly say that he did not belong to the small group of great minds who by major discoveries or great ideas push science ahead to a higher level. No really important discovery is contained in all his work, excellent as it is; his clear and logical mind was, it seems, not imaginative enough to conceive inspiring ideas. But it is also possible that his love for detail and for the cataloguing of details, together with the unbelievable rush of his activities, did not leave time and leisure for quiet thinking. Actually when he had this leisure he surpassed the usual level of his work. In the writer's opinion the best piece of synthetic and analytic writing he did was done after his retirement, when he contributed a masterly paper on the cell theory to a symposium commemorating the centenary of this theory. But though not great, he was a very good zoologist of broad scientific background, interested in many different aspects of the field, taxonomy and distribution, ecology and morphology, evolution, development, cytology and applied science. The quantity alone of the facts described by him makes for him a position in the zoological research of his time. Beyond this he was a conspicuous and successful scientific personality through the intensity of his attack, his power of organization, his readiness to serve the commonweal and his fostering of international good will by reaching out continuously beyond the borders of his country. Thus, the many honors which he received in memberships, honorary fellowships and honorary degrees were the well deserved rewards for a life devoted to the pursuit of science as he saw it. He was elected to the National Academy of Sciences in 1922.

All these data on Kofoid's life and performance reveal, with all its limitations, a remarkable personality and character. I think the meaning of relaxation was completely unknown to him. The predominant traits were clearly the abundance of energy, the hunger for facts, the need of putting things in order, a great sense of civic responsibility and a general Puritanic outlook on life. The intensity of his activity, together with his hard driving of himself and others, made him appear sometimes a hard and forbidding personality. But when he relaxed and allowed a twinkle to appear in his eyes, he could develop a great charm. At such times he was a good conversationalist, always eager to discuss any subject whatever. His great erudition allowed him to comment interestingly on many subjects, and a ready memory put innumerable facts in easy reach of his mind. He was always ready to learn. Even in traveling he was always a student. He was a good traveler, one who tried to enter into the spirit of the countries he visited and to live with the people. If his judgments were not always correct, this was due less to a lack of information than to the Puritanic background of his mind. He enjoyed in his travels, in which he did not mind roughing it, the beauties of nature and also of art, though the understanding of the arts was not his greatest quality. He also thoroughly enjoyed meeting people; he had friends all over the world and liked to recall many an interesting interview. Thus his mind was wide open to the world, though what he saw and experienced did not change his general outlook, which was that of a conservative and Puritan. His strong ethical and specifically Christian background made him a severe judge where he disagreed. But by the same token he was always ready to help causes and persons of which he approved. The present writer has every reason to set down gratefully this trait. Though he lived comfortably and his life was free of material wants, it was also of Puritan simplicity with the exception of a good car which he drove recklessly almost to the last, in spite of many smash-ups and narrow escapes. It was probably also a consequence of his Puritan heritage that he was a very good financier. In the Department he was considered an authority on investment, and the fact that he left a considerable estate, most of which he must have accumulated himself, bears out such reputation. Altogether Charles A. Kofoid was a remarkable personality, a man who owed his success and his high standing in the University and the community to a strong and inflexible character, huge will power, immense capacity for work, and deep ethical convictions.

KEY TO ABBREVIATIONS USED IN BIBLIOGRAPHY

Amer. Assn. Adv. Sci. = American Association for the Advancement of Science
Amer. J. Hyg. = American Journal of Hygiene
Amer. J. Pub. Health = American Journal of Public Health
Amer. J. Trop. Med. = American Journal of Tropical Medicine
Amer. Nat. = American Naturalist
Amer. Soc. Civil Eng. = American Society of Civil Engineers
Amer. Vet. Rev. = American Veterinary Review
Anat. Rec. = Anatomical Record
Ann. Mag. Nat. Hist. = Annals and Magazine of Natural History
Ann. Rept. Amer. Soc. Hyg. Assn. = Annual Report, American Social Hygiene Association
Ann. Rept. United Fruit Co. Med. Dept. = Annual Report, United Fruit Company Medical Department
Arch. Int. Med. = Archives of Internal Medicine
Arch. Ophth. = Archives of Ophthalmology
Arch. Path. = Archives of Pathology
Arch. für Protistenk. = Archiv für Protistenkunde
Bull. Ill. State Lab. Nat. Hist. = Bulletin, Illinois State Laboratory of Natural History
Bull. Mich. Fish Comn. = Bulletin, Michigan Fish Commission
Bull. Mus. Comp. Zool. = Bulletin, Museum of Comparative Zoology, Harvard University
Bull. Musée Roy. d'Hist. Nat. Belg. = Bulletin, Musée Royal d'Histoire Naturelle de Belgique
Bull. Soc. Path. Exot. = Bulletin de la Société de Pathologie Exotique, Paris
Bull. U. S. Bur. Educ. = Bulletin, United States Bureau of Education
Bull. Zool. Soc. San Diego = Bulletin, Zoological Society of San Diego
Calif. State Bd. Health, Bur. Comm. Dis., Div. Paras. = California State Board of Health, Bureau of Communicable Diseases, Division of Parasitology
Calif. State J. Med. = California State Journal of Medicine
Calif. & West. Med. = California and Western Medicine
China Med. J. = China Medical Journal
Gac. Méd. Caracas = Gaceta Médica de Caracas
Internat. Cong. Zool. = International Congress of Zoology
Int. Rev. d. ges. Hydrobiol. u. Hydrogr. — Internationale Revue der Gesamten Hydrobiologie und Hydrographie
J. Amer. Dent. Assn. = Journal, American Dental Association
J. Amer. Med. Assn. = Journal, American Medical Association
J. Amer. Water Works Assn. = Journal, American Water Works Association
J. Appl. Micros. = Journal of Applied Microscopy
J. Lab. Clin. Med. = Journal of Laboratory and Clinical Medicine
J. Med. Res. = Journal of Medical Research
J. Paras. = Journal of Parasitology
J. Pharm. Exper. Therap. = Journal of Pharmacology and Experimental Therapeutics

J. Western Soc. Eng. = Journal, Western Society of Engineers
Mem. Mus. Comp. Zool. = Memoirs, Museum of Comparative Zoology, Harvard University
Mil. Surg. = Military Surgeon
Mo. Bull. Calif. State Bd. Health = Monthly Bulletin, California State Board of Health
New Orleans Med. Surg. J. = New Orleans Medical and Surgical Journal
Pop. Sci. Mo. = Popular Science Monthly
Proc. Amer. Acad. Arts Sci. = Proceedings, American Academy of Arts and Sciences
Proc. Amer. Phil. Soc. = Proceedings, American Philosophical Society
Proc. Internat. Conf. Health Problems Trop. Amer. = Proceedings, International Conference on Health Problems in Tropical America
Proc. Nat. Acad. Sci. = Proceedings, National Academy of Sciences
Proc. N. Y. Path. Soc. = Proceedings, New York Pathological Society
Proc. 2nd Pan Amer. Sci. Cong. Wash. = Proceedings, Second Pan American Scientific Congress, Washington
Proc. 7th Internat. Zoöl. Cong. Boston = Proceedings, Seventh International Zoölogical Congress, Boston
Proc. Soc. Exper. Biol. Med. = Proceedings, Society for Experimental Biology and Medicine
Sci. Amer. = Scientific American
Sci. Mo. = Scientific Monthly
Texas State J. Med. = Texas State Journal of Medicine
Trans. Amer. Gastro-Enterol. Assn. = Transactions, American Gastro-Enterological Association
Trans. Amer. Micros. Soc. = Transactions, American Microscopical Society
Univ. Calif. Mem. = University of California Memoirs
Univ. Calif. Publ. Bot. = University of California Publications in Botany
Univ. Calif. Publ. Zool. = University of California Publications in Zoology
Univ. Texas Bull. = University of Texas Bulletin
Zool. Anz. = Zoologischer Anzeiger
Zool. Bull. = Zoological Bulletin

BIBLIOGRAPHY OF C. A. KOFOID

1894

On some laws of cleavage in Limax. Proc. Amer. Acad. Arts Sci., 29 (n.s. 21) : 180-203, 2 pls.

1895

On the early development of Limax. Bull. Mus. Comp. Zool., 27:35-118, 8 pls. 5 figs.

1896

The Biological Experiment Station. The Illini, 26:665-672, 7 figs.
On the occurrence of Trochosphera solstitialis in the Illinois River. Science, n.s. 4:935-936.

A report upon the Protozoa observed in Lake Michigan and the inland lakes in the neighborhood of Charlevoix, during the summer of 1894. Bull. Mich. Fish Comn., no. 6, Appendix no. 2, pp. 76-84.

1897

On some important sources of error in the plankton method. Science, n.s. 6:829-832.

Plankton studies. I. Methods and apparatus in use in plankton investigations at the Biological Experiment Station of the University of Illinois. Bull. Ill. State Lab. Nat. Hist., 5: art. 1, 1-25, 7 pls.

1898

The fresh-water biological stations of America. Amer. Nat., 32:391-406, 2 figs.

Hints on the construction of a tow-net. J. Appl. Micros., 1:111-113, 5 figs.

Plankton studies. II. On Pleodorina illinoisensis, a new species from the plankton of the Illinois River. Bull. Ill. State Lab. Nat. Hist., 5: art. 5, 273-293, pls. 36-37; Also in Ann. Mag. Nat. Hist., ser. 7, 6:139-156, 1900.

Report of the Superintendent of the Biological Station. Bien. Rept. Ill. State Lab. Nat. Hist., 1897-98, pp. 8-25.

1899

On the specific identity of Cotylaspis insignis Leidy and Platyaspis anodontae Osborn. Zool. Bull., 2:179-186.

Plankton studies. III. On Platydorina, a new genus of the family Volvocidae, from the plankton of the Illinois River. Bull. Ill. State Lab. Nat. Hist., 5: art. 9, 419-440, pl. 38; Also in Ann. Mag. Nat. Hist., ser. 7, 6:541-558, 1900.

1900

Notes on the natural history of Polyodon. Science, n.s. 11:252.

On Platydorina caudata. Science, n.s. 11:252.

The plankton of Echo River, Mammoth Cave. Trans. Amer. Micros. Soc., 21:113-126.

A preliminary account of some of the results of the plankton work of the Illinois Biological Station. Science, n.s. 11:255-258.

1903

On the structure of Protophrya ovicola, a ciliate infusorian from the brood-sac of Littorina rudis Don. *In* Mark Anniversary Volume; to Edward Laurens Mark, Hersey Professor of Anatomy and Director of the Zoological Laboratory at Harvard University. N. Y.: H. Holt and Co., pp. 111-120, pl. 8.

Plankton studies. IV. The plankton of the Illinois River, 1894-1899, with introductory notes upon the hydrography of the Illinois River and its basin. Part I. Quantitative investigations and general results. Bull. Ill. State Lab. Nat. Hist., 6:95-629, 50 pls.

1904

Biological survey of the waters of Southern California by the Marine Laboratory of the University of California at San Diego. Science, n.s. 19:505-508.

1905

Craspedotella, a new genus of the Cystoflagellata, an example of convergence. Reports on the scientific results of the expedition to the eastern tropical Pacific, in charge of Alexander Agassiz, by the U. S. Fish Commission steamer "Albatross," from October, 1904, to March, 1905. Bull. Mus. Comp. Zool., 46:163-165, 1 pl.

A self-closing water bucket for plankton investigations. Conseil Permanent International pour l'Exploration de la Mer. Publications de Circonstance, no. 32, 10 pp., 4 figs.

Some new Tintinnidae from the plankton of the San Diego region. Univ. Calif. Publ. Zool., 1:287-306, pls. 26-27.

1906

Dinoflagellata of the San Diego region. I. On Heterodinium, a new genus of the Peridinidae. Univ. Calif. Publ. Zool., 2:341-368, pls. 17-19.

Dinoflagellata of the San Diego region. II. On *Triposolenia,* a new genus of the Dinophysidae. Univ. Calif. Publ. Zool., 3:93-116, pls. 15-17.

A discussion of species characters in Triposolenia. Univ. Calif. Publ. Zool., 3:117-126.

On the significance of the asymmetry in Triposolenia. Univ. Calif. Publ. Zool., 3:127-133, 2 figs.

On the structure of Gonyaulax triacantha Jörg. Zool. Anz., 30:102-105, 3 figs.

1907

The coincident distribution of related species of pelagic organisms as illustrated by the Chaetognatha. Amer. Nat., 41:241-251, 2 figs.

Dinoflagellata of the San Diego region. III. Descriptions of new species. Univ. Calif. Publ. Zool., 3:299-340, pls. 22-33.

The limitations of isolation in the origin of species. Science, n.s. 25:500-506.

New species of Dinoflagellates. Reports on the scientific results of the expedition to the eastern tropical Pacific, in charge of Alexander Agassiz, by the U. S. Fish Commission steamer "Albatross," from October, 1904, to March, 1905. IX. Bull. Mus. Comp. Zool., 50:163-207, pls. 1-18.

On *Ceratium* eugrammum and its related species. Zool. Anz., 32:25-28, 4 figs.

The plates of *Ceratium* with a note on the unity of the genus. Zool. Anz., 32:177-183, 8 figs.

The San Diego Marine Biological Laboratory. Univ. Calif. Chronicle, 9:37. (A report on the Summer Session)

The structure and systematic position of Polykritos Bütsch. Zool. Anz., 31:291-293, 1 fig.

1908

Cooperation in scientific bibliography. Science, n.s. 27:543-545.

Exuviation, autotomoy and regeneration in *Ceratium.* Science, n.s. 27:948. (Abstract of paper for American Association for the Advancement of Science Sect. F—Zoology, American Society of Zoologists)

Exuviation, autotomy and regeneration in *Ceratium.* Univ. Calif. Publ. Zool., 4:345-386, 33 figs.

Notes on some obscure species of *Ceratium.* Univ. Calif. Publ. Zool., 4:387-393.

Plankton studies. V. The plankton of the Illinois River, 1894-1899, with introductory notes upon the hydrography of the Illinois River and its basin. Part II. Constituent organisms and their seasonal distribution. Bull. Ill. State Lab. Nat. Hist., 8:3-361, 5 pls.

1909

The morphology of the skeleton of *Podolampas.* Arch. für Protistenk., 16:48-61, pl. 3.

Mutations in *Ceratium.* Reports on the scientific results of the expedition to the eastern tropical Pacific, in charge of Alexander Agassiz, by the U. S. Fish Commission steamer "Albatross," from October, 1904, to March, 1905. XX. Bull. Mus. Comp. Zool., 52:213-257, 4 pls., 5 figs.

On *Peridinium steini* Jörgensen, with a note on the nomenclature of the skeleton of the Peridinidae. Arch. für Protistenk., 16:25-47, pl. 2.

1910

The biological stations of Europe. Bull. U. S. Bur. Educ., no. 440, 360 pp., 55 pls., 48 figs.

A great marine museum. Pop. Sci. Mo., 76:196-201, 5 figs.

A revision of the genus *Ceratocorys,* based on skeletal morphology. Univ. Calif. Publ. Zool., 6:177-187.

1911

Contributions of Alexander Agassiz to marine biology. Int. Rev. d. ges. Hydrobiol. u. Hydrogr., 4:39-43, 1 pl.

Dinoflagellata of the San Diego region. IV. The genus *Gonyaulax,* with notes on its skeletal morphology and a discussion of its generic and specific characters. Univ. Calif. Publ. Zool., 8:187-269, 9 pls., 5 figs.

Dinoflagellata of the San Diego Region. V. On *Spiraulax,* a new genus of the Peridinida. Univ. Calif. Publ. Zool., 8:295-300, 1 pl.

The evolution of animal life, the facts and factors. Outline of lectures in general science 2. Univ. Calif. Syllabus Series, no. 23, pp. 1-27.

New genera and species of Dinoflagellates. Reports on the scientific results of the expedition to the eastern tropical Pacific, in charge of Alexander Agassiz, by the U. S. Fish Commission steamer "Albatross," from October, 1904, to March, 1905. XXII. Bull. Mus. Comp. Zool., 54:267-302.

On a self-closing plankton net for horizontal towing. Univ. Calif. Publ. Zool., 8:311-348, pls. 22-25.

On an improved form of self-closing water-bucket for plankton investigations. Univ. Calif. Publ. Zool., 8:349-352, 2 pls.

On the skeletal morphology of *Gonyaulax catenata* (Levander). Univ. Calif. Publ. Zool., 8:287-294, pl. 18.

1912

The evolution of animal life, the facts and factors. Outline of lectures in general science 2. Univ. Calif. Syllabus Series, no. 30, pp. 1-25

The faunal relations of the Dinoflagellata of the San Diego region. Proc. 7th Internat. Zoöl. Cong. Boston, 1907, pp. 922-927. (An advance separate was issued in 1910)

Haeckel's *Sethocephalus eucecryphalus* (Radiolaria) a marine ciliate. Univ. Calif. Publ. Zool., 9:353-357.

A new apparatus for marine exploration. Recently invented deep-sea nets. Sci. Amer., 106:174.

A new horizontal self-closing plankton net. Int. Rev. d. ges. Hydrobiol. u. Hydrogr., 5:91-92, 1 pl.

(With C. M. Haring.) Observations concerning the pathology of roup and chicken-pox. Amer. Vet. Rev., 40:717-728.

(With Edna Earl Watson.) On the orientation of Gyrocotyle and of the cestode strobila. Proc. 7th Internat. Zoöl. Cong. Boston, 1907, pp. 187-191, figs. 1-3. (An advance separate was issued in 1910)

(With Josephine Rigden Michener.) On the structure and relationships of *Dinosphaera palustris* (Lemm.) Univ. Calif. Publ. Zool., 11:21-28, figs. 1-8.

A peculiar form of schizogony in Gonyaulax. Reports on the scientific results of the expedition to the eastern tropical Pacific, in charge of Alexander Agassiz, by the U. S. Fish Commission steamer "Albatross," from October, 1904, to March, 1905. XXIV. Bull. Mus. Comp. Zool. 54:335-348, 2 figs., 2 pls.

Significance of certain forms of asymmetry of the Dinoflagellates. Proc. 7th Internat. Zoöl. Cong. Boston, 1907, pp. 928-931. (An advance separate was issued in 1910)

1914

Die Aufgaben der biologischen Stationen. Int. Rev. d. ges. Hydrobiol. u. Hydrogr., 6:1-16, 1 pl., 2 maps.

Laboratory instructions for zoology. General zoology, first half-year. Univ. Calif. Syllabus Series, no. 50, 58 pp.

Phytomorula regularis, a symmetrical protophyte related to *Coelastrum*. Univ. Calif. Publ. Bot., 6:35-40, pl. 7.

1915

The evolution of the protozoan nucleus and its extranuclear connections. Science, n.s. 42:658. (Abstract of report before American Association for the Advancement of Science, San Francisco, Aug. 6)

Instruction of teachers in sex hygiene. 1st Ann. Rept. Amer. Soc. Hyg. Assn., pp. 116-122.

Marine biology on the Pacific coast. *In* American Association for the Advancement of Science, Pacific Coast Committee. Nature and Science on the Pacific Coast. San Francisco, Paul Elder, pp. 124-132, pls. 16-18, figs. 12-13.

(With Olive Swezy.) Mitosis and mutiple fission in trichomonad flagellates. Proc. Amer. Acad. Arts Sci., 51:289-378, pls. 1-8, figs. A-G.

Mitosis in Trichomonas. Proc. Nat. Acad. Sci., 1:315-321, figs. 1-9.

Notes on the Tintinnoina. 1. On the probable origin of *Dictyocysta tiara* Haeckel. 2. On *Petalotricha entzi* sp. nov. Univ. Calif. Publ. Zool., 16:63-69, figs. 1-8.

(With Elizabeth Bohn Christiansen.) On binary and multiple fission in *Giardia muris* (Grassi). Univ. Calif. Publ. Zool., 16:30-54, pls. 5-8, fig. A.

(With Elizabeth Bohn Christiansen.) On *Giardia microti* sp. nov., from the meadow mouse. Univ. Calif. Publ. Zool., 16:23-29, 1 fig.

On the life-history of *Giardia*. Proc. Nat. Acad. Sci., 1:547-552, 1 fig.

On the relative numbers of rhizopods and flagellates in the fauna of soils. Science, n.s. 42:937-940, 1 fig.

The probable effect of the European war upon the human stock. Calif. Outlook, 17, no. 19:19-23.

A reliable method for obtaining amoeba for class use. Trans Amer. Micros. Soc., 34:271-274.

1916

(With Irene McCulloch.) On *Trypanosoma triatomae,* a new flagellate from a hemipteran bug from the nests of the wood rat *Neotoma fuscipes*. Univ. Calif. Publ. Zool., 16:113-126, pls. 14-15.

1917

The biological and medical significance of the intestinal flagellates. Proc. 2nd Pan Amer. Sci. Cong., Washington, 1915-16, 10:546-565.

Hookworm among miners. Mo. Bull. Calif. State Bd. Health, 13:224-225.

Laboratory instructions for zoology 1A. General zoology, first half-year, 1917-18. Univ. Calif. Syllabus Series, no. 87, 77 pp.

(With Olive Swezy.) On the orientation of *Erythropsis*. Univ. Calif. Publ. Zool., 18:89-102, figs. 1-12.

1917-18

Monthly report of the Biological Division, July 1917-Jan. 1918, Mo. Bull. Calif. State Bd. Health, 13:122-123, 170-171, 224-225, 281, 334, 377-378, 430-431. (Sept. 1917-Mar. 1918)

1918

(With W. W. Cort.) Hookworm a communicable and compensable disease. Mo. Bull. Calif. State Bd. Health, 13:405-414, pls. 1-2, figs. 1-3.

(With W. W. Cort.) Laboratory instructions for zoology 1A. General zoology, first half-year, 1918-1919. Univ. Calif. Syllabus Series. no. 92, 70 pp.

(With Marshall A. Barber.) Rapid method of detection of ova of intestinal parasites in human stools. J. Amer. Med. Assn., 71:1557-1561. *Also issued* as v. 1, no. 1 of Reprint Series in Parasitology, Calif. State Bd. Health, Bur. Comm. Dis., Div. Paras.

(With William W. Cort.) Sanitation in mines for the prevention and eradication of hookworm. Special Bull. Calif. State Bd. Health, no. 28, 12 pp., 2 pls., 3 figs.

1919

(With Sidney I. Kornhauser and Olive Swezy.) Criterions for distinguishing the Endamoeba of amebiasis from other organisms. Arch. Int. Med., 24:35-50, figs. 1-43.

(With Olive Swezy.) Flagellate affinities of Trichonympha. Proc. Nat. Acad. Sci., 5:9-16, figs. 1-10.

(With Sidney I. Kornhauser and J. T. Plate.) Intestinal parasites in overseas and home service troops of the U. S. Army with especial reference to carriers of amebiasis. J. Amer. Med. Assn., 72:1721-1724; *Also issued* as v. 1, no. 6 of Reprint Series in Parasitology, Calif. State Bd. Health, Bur. Comm. Dis., Div. Paras., 11 pp.

Intestinal protozoan infections in United States Army troops. Trans. Amer. Gastro-Enterol. Assn., 22:262-273.

Laboratory instructions for zoology 1A. General zoology, first half-year, 1919-1920. Univ. Calif. Syllabus Series, no. 99, 75 pp.

(With Marshall A. Barber.) Un metodo rapido para encontrar en las heces los huevos de parasitos intestinales. Gac. Med. Caracas, 26: 87-90, 98-101.

(With A. W. White.) A new nematode infection of man. J. Amer. Med. Assn., 72:567-569; *Also issued* as v. 1, no. 4 of Reprint Series in Parasitology, Calif. State Bd. Health, Bur. Comm. Dis., Div. Paras.

(With W. C. Boeck, D. E. Minnich and J. H. Rogers.) On the treatment of giardiasis in rats with arsenobenzol. J. Med. Res. 39 (n.s. 34):293-299. *Also issued* as v. 1, no. 2 of Reprint Series in Parasitology, Calif. State Bd. Health, Bur. Comm. Dis., Div. of Paras.

(With Sidney I. Kornhauser and Olive Swezy.) Structure and systematic relationships of the "iodine cysts" from human feces. Mil. Surg., 45:30-43, 25 figs.

(With Olive Swezy.) Studies on the parasites of the termites. I. On *Streblomastix strix,* a polymastigote flagellate with a linear plasmodial phase. Univ. Calif. Publ. Zool., 20:1-20, pls. 1-2, 1 fig.

(With Olive Swezy.) Studies on the parasites of the termites. II. On *Trichomitus termitidis,* a polymastigote flagellate with a highly developed neuromotor system. Univ. Calif. Publ. Zool., 20:21-40, pls. 3-4, figs. a-b.

(With Olive Swezy.) Studies on the parasites of the termites. III. On *Trichonympha campanula* sp. nov. Univ. Calif. Publ. Zool., 20:41-98, pls. 5-12, figs. a-d.

(With Olive Swezy.) Studies on the parasites of the termites. IV. On *Leidyopsis sphaerica* gen. nov., sp. nov. Univ. Calif. Publ. Zool., 20:99-116, pls. 13-14, fig. A.

1919-20

Summary of examinations made in the Division of Parasitology during August, 1919 (-March 1920). Mo. Bull. Calif. State Bd. Health, 15:115, 155, 199, 231, 264, 294, 316, 336. (Oct. 1919-Apr. 1920)

1920

A critical review of the nomenclature of human intestinal flagellates, Cercomonas, Chilomastix, Trichomonas, Tetratrichomonas, and Giardia. Univ. Calif. Publ. Zool., 20:145-168, figs. 1-9.

(With Olive Swezy.) The flagellate infections of the human digestive tract. Nelson's Loose Leaf Encyclopedia of Living Medicine, 5:365-398, pls. 1-6, figs. 1-59.

Hookworm and amoebiasis in California. Calif. State J. Med., 18:329-332.

(With Pirie Davidson and W. F. Hamilton.) Laboratory instructions for zoology 1A. General zoology, first half-year, 1920-1921. Univ. Calif. Syllabus Series, no. 92.

A new morphological interpretation of the structure of *Noctiluca,* and its bearing on the status of the Cystoflagellata (Haeckel). Univ. Calif. Publ. Zool., 19:317-334, pl. 18, figs. A-I.

(With Olive Swezy.) On the morphology and mitosis of Chilomastix mesnili (Wenyon). A common flagellate of the human intestine. Univ. Calif. Publ. Zool., 20:117-144, pls. 15-17, figs. A-B.

(With Olive Swezy.) On the prevalence of carriers of Endamoeba dysenteriae among soldiers returned from overseas service. New Orleans Med. Surg. J., 73:4-11; *also in* Amer. J. Trop. Med., 1:41-48, 1921.

1921

(Biennial report of the) Division of Parasitology (July 1, 1918, to June 30, 1920). 26th Bien. Rept. Calif. State Bd. Health, pp. 31-33.

(With Olive Swezy.) Councilmania lafleuri, a new amoeba of the human intestine. Proc. Soc. Exper. Biol. Med., 18:310-312.

A critical discussion of the chromidial formation of nuclei, of autogamy, and of the multiple division of polyenergid nuclei, with especial reference to the unity of the mechanism of heredity in the Protozoa and Metazoa. Symposium on fertilization, 81. Anat. Rec., 20:223-225.

(With Olive Swezy.) The free-living unarmored Dinoflagellata. Univ. Calif. Mem., 5, 562 pp., 12 pls., 388 figs.

The marine borers of the San Francisco Bay region. Report San Francisco Marine Piling Survey, 1:23-61, 1 fig. (Revised ed. issued the same year has the same pagination)

(With Olive Swezy.) On the free, encysted, and budding stages of Councilmania lafleuri, a parasitic amoeba of the human intestine. Univ. Calif. Publ. Zool., 20:169-198, pls. 18-22, figs. A-C.

(With John P. Tucker.) On the relationship of infection by hookworm to the incidence of morbidity and mortality in 22,842 men of the United States Army Camp at Bowie, Texas, from October 1917, to April 1918. Amer. J. Hyg., 1:79-117, figs. 1-3.

1921-22

Summary of examinations made in the Division of Parasitology during the month of April, 1921 (-Nov. 1921). Mo. Bull. Calif. State Bd. Health, 17:41, 97, 136, 183, 222, 258, 289. (July 1921-Jan. 1922)

1922

(With L. M. Boyers and Olive Swezy.) Amebiasis in relation to arthritis deformans and to Hodgkin's disease. Proc. N. Y. Path. Soc., n.s. 22:120-126.

(With Luther M. Boyers and Olive Swezy.) Amebiasis of the bones. J. Amer. Med. Assn., 78:1602-1604, figs. 1-7.

(With Robert C. Miller.) Biological section, San Francisco Marine Piling Survey Report, 2:72-82.

(With Olive Swezy and Luther M. Boyers.) The coexistence of Hodgkin's disease and amebiasis. J. Amer. Med. Assn., 78:532, 1147.

(With Luther M. Boyers and Olive Swezy.) Endamoeba dysenteriae in the lymph glands of man in Hodgkin's disease. Univ. Calif. Publ. Zool., 20:309-312, figs. 1-4.

The geographical distribution of hookworm infection in the United States, detected in army recruits. Amer. J. Trop. Med., 2:389-396.

1922-25

Investigation on intestinal protozoa. Yearbook Carnegie Institution of Washington, 21:323; 22:279-280; 23:228-229; 24:283.

Microscopic organisms in reservoirs in relation to the aesthetic qualities of potable waters. J. Amer. Water Works. Assn., 10:183-191.

(With Olive Swezy.) Mitosis and fission in the active and encysted phases of Giardia enterica (Grassi) of man, with a discussion of origin of bilateral symmetry in the polymastigote flagellates. Univ. Calif. Publ. Zool., 20:199-234, pls. 23-26, figs. A-K.

Mitosis in Endamoeba dysenteriae in the bone marrow in arthritis deformans. Univ. Calif. Publ. Zool., 20:301-307, figs. 1-7.

(With Luther M. Boyers and Olive Swezy.) Occurrence of Endameba dysenteriae in the lesions of Hodgkin's disease. J. Amer. Med. Assn., 78:1604-1607, 7 figs.

(With Olive Swezy.) On the occurrence of the Endamoeba dysenteriae in bone lesions in arthritis deformans. Calif. State J. Med., 20:59.

Technique for staining the Amoeba with iron haematoxylin. China Med. J., 36:406-409, 2 pls.

1922-23

(Quarterly report of the) Division of Parasitology, January, 1922-February, 1923. Quart. Bull. Calif. State Bd. Health, v. 1, no. 1, pp. 16-17; v. 1, no. 2, pp. 18, 21, 24; v. 1, no. 3, pp. 25-26; v. 1, no. 4, pp. 23-24; v. 2, no. 1, pp. 21-22.

1923

Amoeba and man. Univ. Calif. Chronicle, 25:149-312, 6 pls.

(Biennial report of) the Division of Parasitology, July 1, 1920, to June 30, 1922. 27th Bien. Rep. Calif. State Bd. Health, pp. 87-95.

(With Robert C. Miller.) Biological section. San Francisco Bay Marine Piling Survey Report, 3:40-55, pls. 1-6, 2 maps.

An early account of the California condor. The Condor, 25:29-30.

The life cycle of the Protozoa. Science, n.s. 57:397-408.

A little known ornithological journal and its editor, Adolphe Boucard, 1839-1904. The Condor, 25:85-89.

(With Henry H. P. Severin and Olive Swezy.) Nelson's spiral bodies in tomato mosaic not protozoans. Phytopathology, 13:330-331.

(With Olive Swezy and John F. Kessel.) On the genus Councilmania, budding intestinal amoebae parasitic in man and rodents. Univ. Calif. Publ. Zool., 20:431-445, figs. 1-19.

(With Olive Swezy.) On the morphology and behavior of Pentatrichomonas ardin delteili (Derrieu and Raynaud). Univ. Calif. Publ. Zool., 20:373-390, pl. 37, fig. A.

Parasitism and evolution. Science, n.s. 57:593. (Abstract of report before National Academy of Sciences, Washington, Apr. 23-25)

Pasteur and the science of biology. Sci. Mo., 16:658-662.

The preservation of our streams and lakes. Izaak Walton League Monthly 1:523, 550.

Preventive medicine and sanitation in relation to human efficiency. J. Western Soc. Eng., 28:195-213, 18 figs., *Also in* Nation's Health, 6:80-82, 1924.

(With Robert C. Miller.) An unusual occurrence of rock boring mollusks in concrete on the Pacific Coast. Science, n.s. 57:383-384.

1924

The cytology of Endamoeba gingivalis (Gros) Brumpt compared with that of E. dysenteriae with special reference to the determination of the amoebas in bone marrow in arthritis deformans of Ely's second type. Univ. Calif. Publ. Zool., 26:165-198, pls. 14-18, figs. A-G; *Also in* J. Amer. Dent. Assn., 12:175-196, 1925.

(With Olive Swezy.) Karyamoeba falcata, a new amoeba from the human intestinal tract. Univ. Calif. Publ. Zool., 26:221-242, pls. 23-24, figs. A-B.

(With Olive Swezy.) A note on Dr. Gunn's difficulties with Councilmania. J. Paras., 10:153-157.

On guard at the southern gate. Nation's Health, 6:790-791.

On the distinctions between Endamoeba coli and Councilmania lafleuri. Univ. Calif. Publ. Zool., 26:21-39, figs. 1-24.

On the revealing and concealing coloration of birds: an unpublished letter by Theodore Roosevelt. The Condor, 26:94-98, 1 fig.

Outwitting the marine borers. Popular Research Narratives, 1:74-76. Engineering Foundation, Baltimore, Williams & Wilkins. (Presented Feb. 1, 1922)

(With Olive Swezy.) Pentatrichomoniasis in man. Amer. J. Trop. Med., 4:33-41, 1 fig.

Ravages of the Teredo in San Francisco Bay. Calif. Month., 18:215-216, 3 figs.

(With Luther M. Boyers and Olive Swezy.) Systemic infections by Endamoeba dysenteriae. Proc. Internat. Conf. Health Problems Trop. Amer., Kingston, Jamaica, p. 381-399.

1925

(With Edna Hannibal Wagener.) The behavior of Endamoeba dysenteriae in mixed cultures with bacteria. Univ. Calif. Publ. Zool., 28:127-154, pls. 13-15.

(With Luther M. Boyers and Olive Swezy.) Chronic human amebiasis: a review of the diagnosis and treatment on the basis of encystment in the liver area. J. Amer. Med. Assn., 85:1441-1447, figs. 1-6.

The hardy Teredo. Architect and Engineer, 81:105-108, 2 figs.

Human amoebiasis with special reference to the chronic phase. Texas State J. Med., 21:347-350.

The human values in biology. Univ. Texas Bull., no. 2545:26-42.

(With Olive Swezy.) Karyamoebina substituted for Karyamoeba, with a note on its occurrence in man. Uinv. Calif. Publ. Zool., 26:435-436.

(With Olive Swezy.) On the number of chromosomes and the type of mitosis in Endamoeba dysenteriae. Univ. Calif. Publ. Zool., 26:331-352, pls. 31-33, fig. A.

(With Olive Swezy and Luther M. Boyers.) A report on an investigation of intestinal protozoan infections at Santa Marta, Colombia, in the hospital of the United Fruit Company, with special reference to the incidence of amoebiasis. Ann. Rept. United Fruit Co., Med. Dept., 14:140-153.

(With Edna Hannibal Wagener.) Studies of the effects of certain drugs upon Endamoeba dysenteriae in vitro. Univ. Calif. Publ. Zool., 28:155-166.

1926

Hand washing, a health ritual. Nation's Health, 8:265-266.

The occurrence of cysts of Councilmania lafleuri Kofoid and Swezy in the duodenal drainage. Proc. Soc. Exper. Biol. Med., 23:299.

(With Olive Swezy.) On Oxymonas, a flagellate with an extensile and retractile proboscis from Kalotermes from British Guiana. Univ. Calif. Publ. Zool., 28:285-300, pl. 30, figs. a-e.

On Oxyphysis oxytoxoides gen. nov., sp. nov. A dinophysoid dinoflagellate convergent toward the peridinioid type. Univ. Calif. Publ. Zool., 28:203-216, pl. 18.

(With Olive Swezy.) On Proboscidiella multinucleata gen. nov., sp. nov., from Planocryptotermes nocens from the Philippine Islands, a multinucleate flagellate with a remarkable organ of attachment. Univ. Calif. Publ. Zool., 28:301-316, pls. 31-32, figs. a-d.

(With Ena A. Allen.) On the culture in vitro of Councilmania laflueri and Endamoeba coli. Proc. Soc. Exper. Biol. Med., 23:300-301.

(With Edna Hannibal Wagener.) A simplified medium for the cultivation of Endameba dysenteriae. J. Lab. Clin. Med., 11:683.

Statistical summary of fecal examinations for protozoa and worms made in the Division of Parasitology, State Hygienic Laboratory, California

State Board of Health, for the biennium July 1, 1924 to June 30, 1926. 29th Bien. Rept. Calif. State Bd. Health, pp. 93-94.

Statistical summary of persons examined for protozoa and worms in the Division of Parasitology, State Hygienic Laboratory, California State Board of Health, for the biennium July 1, 1924 to June 30, 1926. 29th Bien. Rept. Calif. State Bd. Health, p. 93.

1927

(With Robert Miller, et al.) Biological section. Marine borers and their relation to marine construction on the Pacific Coast. Final report of the San Francisco Bay Marine Piling Committee, pp. 188-351, figs. 68-143, tables 28-45.

(Greater efficiency of E. B. I. and emetine in treating infection with *Entamoeba histolytica;* a new amoeba, *Councilmania dissimilis.*) Lancet, 213:707. (Abstract of report before British Medical Association Annual meeting, Edinburgh, July 20)

The higher values of the zoological park. Bull. Zool. Soc. San Diego, no. 2, 16 pp.

(C. L. Hill and C. A. Kofoid, editors.) Marine borers and their relation to marine construction of the Pacific Coast, being the final report of the San Francisco Bay Marine Piling Committee, prepared under the direction of the San Francisco Bay Marine Piling Committee, cooperating with the National Research Council and the American Wood-preservers' Association. 357 pp., 143 figs., 45 tables, 1 map.

On Councilmania dissimilis sp. nov., an intestinal amoeba from man. Univ. Calif. Publ. Zool., 31:7-16, pls. 1-2.

1928

Councilmania tenuis and C. dissimilis, intestinal amebas of man. Arch. Int. Med., 41:558-573, figs. 1-5.

(With Tage Skogsberg.) The Dinoflagellata: the Dinophysoidae. Reports on the scientific results of the expedition to the eastern tropical Pacific, in charge of Alexander Agassiz, by the U. S. Fish Commission steamer "Albatross," from October, 1904, to March, 1905. XXXV. Mem. Mus. Comp. Zool., 51:1-766, 31 pls., 103 figs.

(With Elizabeth Custer Nasset.) The effects of radium and radium in combination with metallic sensitizers on Endamoeba dysenteriae in vitro. Univ. Calif. Publ. Zool., 31:387-416, pls. 16-17, figs. 1-7.

Intestinal parasites. *In* The Medical Department of the United States Army in the World War, U. S. Surgeon-General's Office, v. 9. Communicable and Other Diseases, by Joseph F. Siler, pp. 529-549.

(With Mary Louise Dodds.) Relationships of the Opalininae. Anat. Rec., 41:51.

1929

About termites. Calif. Month., 22:11-13, 52, 3 figs.

(With H. Corwin Hinshaw and Herbert G. Johnstone.) Animal parasites of the mouth and their relation to dental disease. J. Amer. Dental Assn., 16:1436-1455, figs. 1-5.

Biennial report of the Division of Parasitology, July 1, 1926 to June 30, 1928. 30th Bien. Rept. Calif. Dept. Pub. Health, pp. 122-125.

(With Arthur S. Campbell.) A conspectus of the marine and fresh-water ciliata belonging to the suborder Tintinnoinea, with descriptions of new species principally from the Agassiz expedition to the eastern tropical Pacific, 1904-1905. Univ. Calif. Publ. Zool., 34:1-403, figs. 1-697.

(With Herbert G. Johnstone.) The cultivation of Endameba gingivalis (Gros) from the human mouth. Amer. J. Pub. Health, 19:549-552.

The genus Councilmania, amoeba parasitic in man and rodents. 10. Internat. Cong. Zool., Budapest, pp. 861-878, 6 figs.

(With E. A. Garland.) Mode of attack of the sound-wood termite on a city building. Architect and Engineer, 99, no. 2:87-90, 2 figs.

The protozoa of the human mouth. J. Paras., 15:151-174. (Presidential address, American Society of Parasitologists, New York, Dec. 29, 1928)

Termites in relation to buildings, and other industrial uses of wood. Proc. San Francisco section, Amer. Soc. Civil Eng., 25, no. 1, pp. 4-8.

Why is there a termite problem in California? Report on the symposium on termite problems of the Termite Investigations Committee, Sept. 2-13, 1929, San Francisco, pp. 15-23; *Also in* Proc. 26th Annual Meeting Amer. Wood-Preservers' Assn., 1930. pp. 298-306.

1930

Factors in the evolution of the pelagic ciliata, the Tintinnoinea. Contributions to Marine Biology, Stanford Univ. Press, pp. 1-39, figs. 1-31.

(With Herbert G. Johnstone.) The oral amoeba of monkeys. Univ.

Chronic amoebiasis. (Proc. 8th Japanese Medical Congress, Osaka. (Nippon igakkaishi)), pp. 73-83.

(With Ronald F. MacLennan.) Ciliates from Bos indicus Linn. I. The genus Entodinium Stein. Univ. Calif. Publ. Zool., 33:471-544, pls. 49-52, figs. A-Q.

Calif. Publ. Zool., 33:379-392, pls. 41-42.

1931

(With Ethel McNeil and M. J. Kopac.) Chemical nature of the cyst wall in human intestinal protozoa. Proc. Soc. Exper. Biol. Med., 29:100-102.

Protozoan fauna of Mutsu Bay. Subclass Dinoflagellata; Tribe Gymnodiniodae. Report of the biological survey of Mutsu Bay. 18. Sci. Reports, Tohoku Imp. Univ. Sendai, ser. 4, Biology, 6:1-43, 3 pls., 12 figs.

1932

(With Ethel McNeil.) The advantages of Locke's blood medium in the culture of parasitic protozoa of the digestive tract. Amer. J. Hyg., 15:315-317.

(With R. F. MacLennan.) Ciliates from Bos indicus Linn. II. A revision of Diplodinium Schuberg. Univ. Calif. Publ. Zool., 37:53-152, pls. 4-7, figs. A-J.

(With Ethel McNeil and Relda Cailleau.) Electrometric pH determinations of the walls and contents of the gastro-intestinal tracts of normal albino rats. Univ. Calif. Publ. Zool., 36:347-355.

1933

(With R. F. MacLennan.) Ciliates from Bos indicus Linn. III. Epidinium Crawley, Epiplastron gen. nov., and Ophryoscolex Stein. Univ. Calif. Publ. Zool., 39:1-33, 1 pl., figs. A-E.

(With E. McNeil and A. Bonestell.) Correlation of the distribution of the protozoa in the intestine of Rattus norvegicus with the hydrogen ion concentration of the intestinal contents and wall. Univ. Calif. Publ. Zool., 39:179-190, figs. 1-3.

(With Alastair Martin Adamson.) The Dinoflagellata: the family Heterodiniidae of the Peridiniodiae. Reports on the scientific results of the expedition to the eastern tropical Pacific, in charge of Alexander Agassiz, by the U. S. Fish Commission steamer "Albatross," from October, 1904, to March, 1905. XXXVI. Mem. Mus. Comp. Zool., 54:3-136, 22 pls.

(With E. McNeil and A. E. Bonestell.) Diseased rats showing increase of Giardia and a septicemic Bacillus coli. Proc. Soc. Exper. Biol. Med., 30:1339-1341.

(With Fae Donat.) Experimental infection with Trypanosoma cruzi from intestine of cone-nose bug, Triatoma protracta. Proc. Soc. Exper. Biol. Med., 30:489-491.

(With Fae Donat.) The experimental transfer of *Trypanosoma cruzi* from naturally infected *Triatoma protracta* to mammals in California. Bull. Soc. Path. Exot., 26:257-259.

(With Fae Donat.) South American trypanosomiasis of the human type —occurrence in mammals in the United States. Calif. and West. Med., 38:245-249, figs. 1-5.

1934

American trypanosomiasis. The northward extension of Brazilian trypanosomiasis, or Chagas' disease, among mammals in California. Proc. 5th Pacific Sci. Cong., Vancouver, 1933, 4:3075-3078.

Arsine hazard; arsenic not a termite barrier. Architect and Engineer, 119, no. 1:47-50.

(With John F. Christenson.) Ciliates from Bos gaurus H. Smith. Univ. Calif. Publ. Zool., 39:341-391, pls. 25-29, figs. A-G.

The distribution of the pelagic ciliates in the eastern tropical Pacific. Proc. 5th Pacific Sci. Cong., Vancouver, 1933, 3:2159-2161.

An interpretation of the conflicting views as to the life cycle of the Foraminifera. Science, n.s. 79: 436-437.

(C. A. Kofoid, editor and contributor.) Termites and termite control. Berkeley, Univ. Calif. Press. 795 pp., 182 figs. (Issued Jan. 1934; 2nd ed. rev., Dec. 1934.)

What to do about termites. Progressive Contractor, 15:10-12, 2 figs.

1935

The biological significance of the life cycle of the Protozoa. Moscow. Vsesoiuznyi Institut Eksperimental noi Meditsiny. Otdel Meditsinskoi Parazitologii, Trudy, v. 1. Parasity, Perenoschiki i Iadovitye Zhivotnye, p. 373-376. ("Receuil des travaux dédié au 25-me anniversaire scientifique du Professeur Eugene Pavlovsky, 1909-1934".)

(With E. McNeil and A. E. Bonestell.) A comparison of the distribution of the intestinal protozoa of the Norway rat, wood rat, and guinea pig with reference to the hydrogen ion concentrations as determined by the glass electrode. Univ. Calif. Publ. Zool., 41:1-8.

(With F. D. Wood and E. McNeil.) The cycle of Trypanosoma cruzi in tissue culture of embryonic heart muscle. Univ. Calif. Publ. Zool., 41:23-24.

The fight against termites. Sci. Mo., 40:275-278.

(With Owen L. Williams.) The nematode Thelazia californiensis as a parasite of the eye of man in California. Arch. Ophth., 13: 176-180, figs. 1-5.

On two remarkable ciliate Protozoa from the caecum of the Indian elephant. Proc. Nat. Acad. Sci., 21:501-506, figs. 1-5.

The termite fight. Architect and Engineer, 120:45-48.

1936

(With F. Forest Whedon.) (Dinoflagellata of the San Francisco region. I. On the skeletal morphology of two new species, Gonyaulax catenella and G. acatenella. Univ. Calif. Publ. Zool., 41:25-34, figs. 1-16.

Has biology advanced in the last twenty-five years? Univ. of Southern Calif. Proceedings 25th Anniversary Celebration of the Inauguration of Graduate Studies, p. 229-235.

(With Mildred Bush.) The life cycle of *Parachaenia myae* gen. nov., sp. nov., a ciliate parasitic in *Mya arenaria* Linn. from San Francisco Bay, California. Bull. Musée Roy. d'Hist. Nat. Belg., 12, no. 22: 1-15, figs. 1-29.

(With Bruce G. Whitaker.) Natural infection of American human trypanosomiasis in two species of cone-nosed bugs, *Triatoma protracta* Uhler and *Triatoma uhleri* Neiva, in the western United States. J. Paras., 22:259-263.

1937

(With Datus M. Hammond.) Continuity of structure and function in the neuromotor system of Euplotes patella during its life cycle. Proc. Amer. Phil. Soc., 77:207-218, pls. 1-3.

(With Ethel McNeil and Fae D. Wood.) Effects of arsenicals on Trypanosoma cruzi in tissue culture. J. Pharm. Exper. Therap., 59:424-428.

(With James T. Park.) A new trematode, Paramphistomum castori sp. nov., from Castor canadensis baileyi Nelson, from Mary's River, Nevada. Univ. Calif. Publ. Zool., 41:419-422, 1 fig.

(With Ethel McNeil.) Notes on various media used in the culture of intestinal protozoa. *In* Culture Methods for Invertebrate Animals, by Paul S. Galtsoff *et al*, Ithaca, N. Y., Comstock Pub. Co., pp. 86-89.

(With Hermann Sommer, W. F. Whedon and R. Stohler.) Relation of paralytic shell-fish poison to certain plankton organisms of the genus Gonyaulax. Arch. Path., 24:537-559, figs. 1-2.

(With Owen L. Williams and N. C. Veale.) Thelazia californiensis, a nematode eye worm of dog and man, with a review of the thelazias of domestic animals. Univ. Calif. Publ. Zool., 41:225-233.

1938

Francis Orpen Morris: ornithologist and anti-Darwinist. Auk, 55:496-500.

(With Datus M. Hammond.) The neuromotor system of Anaplophrya lumbrici, a degenerate ciliate, from the earthworm Octolasium cyaneum. Proc. Amer. Phil. Soc., 78:595-612, pls. 1-2.

(With W. R. Hinshaw and E. McNeil.) The presence and distribution of *Hexamita* sp. in turkeys in California. J. Amer. Med. Assn., 93:160.

(With W. R. Hinshaw and E. McNeil.) The relationship of *Hexamita* sp. to an enteritis of turkey poults. Cornell Veterinarian, 28:281-293.

1939

(With Arthur Shackleton Campbell.) The Ciliata: the Tintinnoinea. Reports on the scientific results of the expedition to the eastern tropical Pacific in charge of Alexander Agassiz by the U. S. Fish Commission steamer "Albatross," from October, 1904, to March, 1905. XXXVII. Bull. Mus. Comp. Zool., 84:1-473, 36 pls.

George Henry Falkiner Nuttall (1862-1937.) Proc. Amer. Acad. Arts Sci., 73:139-141.

The significance of the number of flagella in Trichomonadae. Volumen Jubilare pro Prof. Sadao Yoshida, Osaka, 2:59-64.

1940

(With H. R. Wessenberg and Ethel McNeil.) The action of carbarsone and two nitrogen-free organic arsenicals, 4-p-propenoneoxy-phenylarsonic acid and p-2-propanol-oxy-phenylarsonic acid, on the intestinal protozoa of rats. Univ. Calif. Publ. Pharmacology, 1:291-300.

Cell and organism. *In* The Cell and Protoplasm, Amer. Assn. Adv. Sci., Pub. no. 14, pp. 98-105.

(With Lauren E. Rosenberg.) Neuromotor system of *Opisthonecta henneguyi* (Faure-Fremiet). Proc. Amer. Phil. Soc., 82:421-430, 1 pl., figs. A-D.

(With E. McNeil and W. R. Hinshaw.) *Hexamita meleagridis* sp. nov. from the turkey. Amer. J. Hyg., Sect. C., 34:71-82, 1 fig.

The life cycle of the Protozoa. *In* Protozoa in Biological Research, by Gary N. Calkins, N. Y.: Columbia Univ. Press., pp. 563-582, figs. 135-139.

1942

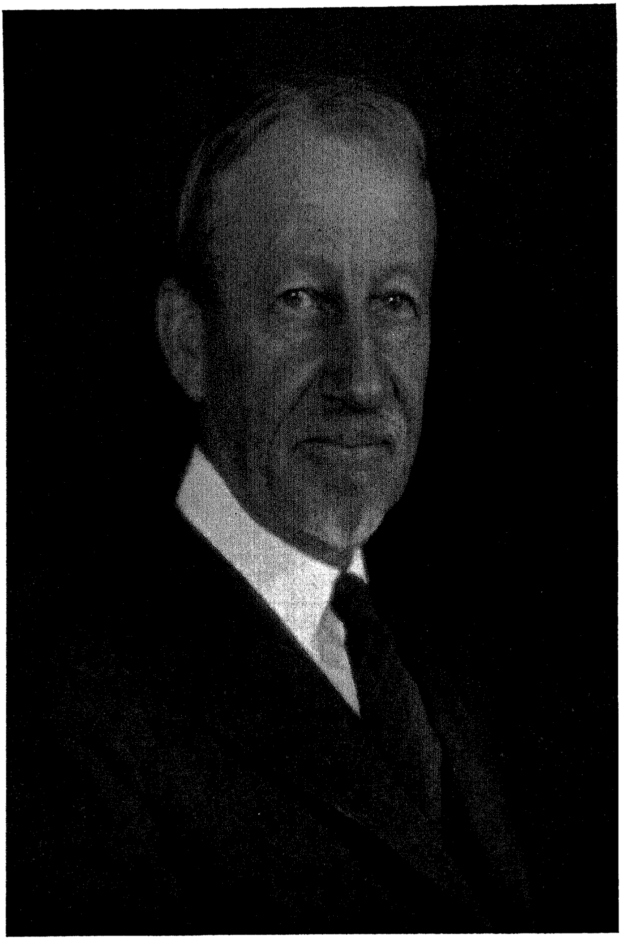
The social aspects of the epidemiology of amoebic dysentery. Proc. 6th Pacific Sci. Cong., Berkeley, 1939, 5:7-10.

1943

An American pioneer in science, Dr. William Charles Wells, 1757-1817. Sci. Mo., 57:77-80.

1948

(With Mildred Bush.) Ciliates from the Sierra bighorn, Ovis canadensis sierrae Grinnell. Univ. Calif. Publ. Zool., 53:237-262, pls. 24-25.



W. H. Howell

WILLIAM HENRY HOWELL[1]

1860–1945

BY JOSEPH ERLANGER

The death of William H. Howell at Baltimore on February 6th, 1945, marked the passing of the galaxy of clinical and scientific talent entrusted with the organization of the departments of the Medical School of Johns Hopkins University prior to the opening of its doors to students of medicine in 1893, and of those of the charter members of the American Physiological Society who devoted their lives to academic careers in physiology. With his death America lost a leading figure in physiological science.

William Henry Howell, born in Baltimore, Maryland, February 20, 1860, was the son of George Henry and Virginia Magruder Howell. He was the fourth child of a family of four sons and one daughter. Both parents were natives of Maryland, coming of families that had lived since 1651 in the southern counties (Charles and Prince Georges) of the State. His father, after his marriage, moved to Baltimore where he engaged in commercial pursuits.

Education

The whole of Howell's formal education was acquired in Baltimore—in the public grade and high schools and in Johns

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[1] The principal sources of material for this biography have been:

A. A brief autobiographic sketch filed with the National Academy of Sciences.

B. Some typed notes of what may have been an address delivered by Howell, probably about 1927.

C. A letter from Howell to the National Academy in response to a request to enumerate his "discoveries."

D. Howell's response on the occasion of "The Celebration of the Sixtieth Anniversary of Dr. William H. Howell's Graduation" (Johns Hopk. Hosp. Bull., 68: 291, 1941).

E. Some notes dealing with personal matters supplied by Janet Howell Clark.

F. History of the American Physiological Society, Baltimore, 1938.

G. Some notes on the organization of the School of Hygiene supplied by Dr. Clark.

The sources of passages quoted from the above are indicated in the text by corresponding letters.

Hopkins University. It was during his student days at the City College, as the high school then was designated, that his interest in science was kindled. At the age of fifteen he was appointed assistant to the professor of physics and chemistry there. In this capacity his duties were, as Howell playfully states it, "to prepare the class demonstrations in physics and chemistry and also to do some polishing of the handle of the big front door" (D). With the encouragement of his science teacher, the lad did some experimenting on his own initiative. Howell mentions particularly repeating Wöhler's classical (1828) experiment of converting ammonium cyanate into urea, the first demonstration of a test-tube conversion of an inorganic into an organic compound. This experience awakened in Howell an interest in medicine. While still in his senior year he left high school, applied for admission to Johns Hopkins University, and, after a personal interview with President Gilman, was accepted. There he pursued the chemical-biological course, designed by the University primarily as a preparation for a career in medicine.

Little is known regarding his activities as an undergraduate student. He must have been athletically inclined as a statement imputed to Henry Thomas describes him as an outstanding football player, especially skillful in tackling. There are indications that, as an undergraduate, Howell was not averse to participating in student pranks. During his college days Darwinian evolution was a subject of bitter controversy and many students became enthusiastic and obstreperous evolutionists. Howell relates (B) how they bought and surreptitiously installed in the university library a plaster cast of Darwin, how President Gilman remonstrated with them and how, at the latter's suggestion, busts of other naturalists were placed in the library, thus lessening the influence of Darwin's presence.

Upon graduation with the degree of bachelor of arts, Howell, in 1881, was awarded a graduate scholarship and consequently matriculated in the graduate school as a candidate for the degree of Doctor of Philosophy. That he had not abandoned his original intention of studying medicine is indicated by the fact that during his candidacy for the Ph.D. degree he took courses in anatomy and clinical medicine at the Medical School of the University of Maryland.

Howell's student days at Hopkins, from 1878 to 1884, coincided with the flowering of that institution into the foremost graduate school in America. Among those who were students during Howell's undergraduate and graduate years and ultimately became Doctors of Philosophy were Henry Crew, H. H. Donaldson, E. H. Hall, W. A. Noyes, H. F. Reid, Josiah Royce and E. B. Wilson, all of whom became members of the National Academy of Sciences. Many others achieved distinction in non-scientific walks of life, e.g., Maurice Bloomfield, G. W. Bright, John Dewey, K. Mitsukuri, Albert Shaw, A. W. Small, Woodrow Wilson, etc. Association with such as these must have had an influence in shaping Howell's character and interests, but as to this there is available no specific information. The faculty of that period also was unique. Howell mentions particularly his acquaintance with Gilman. Of him he writes (D) that as a graduate student, a fellow, and finally as a member of the faculty his contacts with him became increasingly more frequent and intimate. Mention is made also of W. Keith Brooks, professor of zoology, and Ira Remsen, professor of chemistry, but particularly of H. Newell Martin, head of the department of biology in which Howell majored. Of Martin he says, "He was my teacher and mentor in physiology. I owe him much; I had a very great affection for him" (F).

The degree of Doctor of Philosophy was awarded Howell in 1884. His dissertation deals with "The Origin of Fibrin Formed in the Coagulation of the Blood" (7). When Howell began this investigation two views were held with regard to the formation of fibrin. Schmidt believed that it is formed by a fermentation process, the substrate being furnished by fibrinogen and paraglobulin, whereas Hammarsten maintained that only fibrinogen and ferment are needed for the formation of a clot. Howell points out that Hammarsten's observations were not conclusive because his solutions of fibrinogen, made from mammalian blood, were not entirely free of globulin. By using blood of the terrapin, Howell was able to secure fibrinogen entirely free of globulin and found that clotting still occurred with the purified reagents, a result that has withstood the test of time. This study was the first of a number of papers on blood clotting, the problem which later became the major interest of Howell's life, and the subject with which his name will be associated through the years.

It was during Howell's student days that Martin described his important experiments upon the isolated mammalian heart, then a new procedure in physiology. Howell assisted Martin in the performance of some of these experiments, and in addition published five papers bearing his own name. All are significant, but one of them (4), published in the Philosophical Transactions of the Royal Society, merits special mention. In this research it was found that the output values per beat of the excised, perfused heart of the dog are 1/855 and (with a slow pulse) 1/700 of the body weight. These are values that agree well with those (1/800 and 1/700) obtained in 1924[2] with improved methods and with the heart in situ.

As a Member of Martin's Department

Upon graduation in 1884 Howell was made chief assistant in Martin's department with the title of assistant professor of biology, and given charge of the laboratory course in animal physiology. In 1888 his title became associate professor in physiology. The courses he taught covered a wide range of subjects—animal morphology, vertebrate histology, mammalian anatomy and animal physiology. There is little additional information available concerning this period of his life. Henry Crew, whose residence at Hopkins overlapped Howell's, writes that "although physiology is quite outside my line, I was early inspired by Howell's style when he now and then read a paper—or discussed another's paper—before the Johns Hopkins University Science Club in the early eighties. . . . That 'unhurried' style and that 'directness and simplicity' of language—delighted me as a young man." Crew speaks also of Howell's imperturbable calm and his absolute sincerity and adds that his clear and ready English, combined with his ability as a listener, made him a master of the art of conversation. John Slade Ely, who collaborated with Howell during the first year of the latter's fellowship and who later became a professor of medicine in Yale, wrote that "he had found in Baltimore a man (Howell) who knew all of physiology and yet was fond of reading Shakespeare" (D).

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[2] E. K. Marshall, Amer. J. Physiol., 79: 459, 1924.

Three papers were published during the four-year period (from 1885 to 1889) of Howell's connection with Martin's department as a staff member. Reference can be made to but one of them, one that led Howell to conclude that coagulation of the blood of limulus is due to a coalescence of corpuscles which then takes on the properties of fibrin (8), a view that has been confirmed by others.[3] One wonders whether the seeming relative inactivity of this period might not have been the result of increasing departmental responsibilities due, perhaps in part, to Martin's failing health. Yet Howell says that the experience of those years stands out in his memory as the golden period of his life (B).

Nearly all students of this period who became professional physiologists worked, often for years, in foreign laboratories, but Howell's only opportunity to gain foreign experience came during a summer's trip abroad at about this time. He elected to go to Munich to see Voit's laboratory, as the great new addition to physiology at that time was Voit's work in nutrition. "The laboratory," Howell wrote many years later (B), "exemplified the Gemütlichkeit which was traditional in Bavaria. At the meeting of the Gesellshaft the members sat around tables drinking Münchener beer while listening to papers and discussions and after the meeting the younger group adjourned to a nearby Keller where the discussion was continued with the help of a plentiful supply of Rhine wine." Howell mentions also a visit to Kühne's laboratory at Heidelberg (B). Apparently he did no investigative work at either place. The laboratories he visited, however, were devoted largely to aspects of chemical physiology. The choice possibly is indicative of

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[3] L. Loeb, Biochem. Zeitschr., 24:95, 1910.

Howell's interest in that phase of physiology, an interest that is exemplified by the immense amount of time he later devoted to the identification of chemical reactants in the process of blood coagulation.

Ann Arbor and Harvard Periods

In 1889 Howell was called to Ann Arbor to succeed Henry Sewall who was giving up the chair in physiology because of ill health. Howell's initial title was lecturer in physiology and histology, but at the close of the first year he was advanced to the professorship in these subjects. An interesting note on Howell's experiences at Ann Arbor appears in an unpublished article by J. S. Lombard, dealing with the history of the department of physiology at Ann Arbor.[4] "It was not easy," Lombard writes, "to lecture to a mixed class of women and men, composed of students from the medical, homeopathic, dental, and liberal arts departments, some of whom, at least, had the reputation of being unruly. Howell concealed beneath a quiet, mild manner great strength of character, which came to the fore when certain students tried to take advantage of him. Howell decided that either they or he would leave the University. The students left, and he had no further trouble with his classes." Lombard is the authority for the statement that in 1891 a laboratory course in physiology became a requirement for all students at Ann Arbor, the first laboratory course in physiology to be required in any medical school of the country.

Howell's stay at Ann Arbor was brief, for in 1892, he accepted appointment as associate professor of physiology under H. P. Bowditch at the Harvard Medical School, where he remained for but one year. Before the termination of that year, Mr. Gilman, the president of Johns Hopkins University, called on Howell in Boston, told him of the plans for a new medical school in Baltimore and offered him the chair in physiology. Howell accepted at once without discussion, for, as he puts it, "I had . . . a deep affection for the University that had done so much for me, everything, in fact, so far as my career was concerned" (D). It is of interest to note here that of those who first headed the four preclinical departments of Hopkins, Howell alone was without extensive experience as a worker in foreign laboratories.

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[4] Supplied through the kindness of F. G. Novy.

Five papers were published during the Ann Arbor-Harvard period. In keeping with Howell's dual title at Ann Arbor these studies dealt as much with structure as with function. Three of the papers deserve special mention. In one (12) there is a description of particles in red blood corpuscles that take nuclear stains, which today (59 years later) are generally known as Howell-Jolly bodies. The other two papers (14 and 15) (published in three parts in collaboration with Huber) dealt with nerve degeneration and regeneration; this work was awarded the Weir Mitchell prize. The papers describe for the first time a number of regeneration processes, such, for example, as the general downward advance of medullation. They also describe, *quite independently* of v. Büngner,[5] the changes in the Schwann cells that result in the formation of what are now generally known as the "bands of v. Büngner."

Here it is necessary to digress in order to refer to Howell's reply to a letter from the Committee on Biographical Memoirs of the National Academy of Sciences. "I find it difficult," he wrote, "to comply with the request of your committee. My work, like that of most scientific men, has consisted largely in contributions to problems of current interest that have been useful, I believe, in throwing light upon the solutions reached but which considered alone can not be reckoned as discoveries. I may, however, cite three cases in which concrete facts of importance were discovered." The first of the discoveries mentioned belongs to this period. It was believed prior to Howell's work that serum albumen was required for the nourishment of the heart. Thus German investigators had found that peptone solutions, which do not support the heartbeat, will do so after they have been in contact with the mucous membrane of the stomach or intestine; and these investigators consequently had assumed that the peptone had been changed to serum albumen. Howell showed (16) that what happened in such cases was that inorganic salts had been added to the solution by diffusion and that it was those salts which maintained the beat of the heart, not proteins.

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[5] Beitr. path. Anat., 10: 321, 1891.

Howell at Johns Hopkins: the Medical School

During the Hopkins period, which extended through the rest of Howell's life, some 55 papers were published. It will be possible to refer specifically to only a few of the more significant of these. Such a paper was the very first of this series (18). Howell found that a nerve can be so treated that it will fail to conduct impulses before its demarcation potential has completely disappeared. He found that such agents cause failure of conduction before complete depolarization is attained.[6]

Howell's interest in the physiology of sleep led to the investigation of the effect of arterial pressure on the flow of blood through the brain. It was believed at the time that an increase in arterial pressure beyond the normal limits reduces the blood flow through the brain. Howell showed by a faultless technique (21) that the blood flow changes linearly with the arterial pressure even through extreme ranges. In another paper (24) observations were made on vasomotor responses of intracranial structures to electrical and to chemical stimuli. It was found that the dura mater is very sensitive to mechanical stimuli—indeed, that to gentle mechanical stimulation the dura seems more irritable than other sensory membranes of the body. Yet, apparently, it was not until 1938[7] that surgeons generally came to realize that there is a nerve distribution to the dura apart from that to its blood vessels.

Howell's interest in salt action (many of his students were assigned problems in this field) suggested to him the possibility that cardiac stoppage resulting from vagus stimulation might be due to the liberation of diffusible potassium in the heart. Guided by this hypothesis, he demonstrated that potassium actually is liberated during vagus stimulation, and in amounts sufficient to stop the heart (29, 32, 33). Later, Loewi found that acetylcholine is liberated during vagus stimulation, that atropine stops the action of acetylcholine but not that of potassium and consequently he concluded that acetylcholine is the inhibitor. However, it has been shown more recently by Lenhartz that acetylcholine liberates potassium, but not in the presence of atropine. It seems, therefore, that potassium actually is the chemical mediator of the action of the vagus on the heart, though this view is not generally accepted. Howell was the first investigator to suggest that the two lobes of the pituitary gland are functionally different. In a paper (20) read by invitation before the first Congress of American Physicians and Surgeons he described experiments showing that the circulatory effects of extracts of the pituitary gland are due entirely to substances derived from the posterior lobe. Ever since that time a distinction has been made between the functions of the lobes. This is the second of the three discoveries mentioned in Howell's letter to the Academy.

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[6] G. H. Bishop, Amer. J. Physiol., 97: 504, 1931.

[7] Proc. Assn. Res. Nerv. and Ment. Dis., 23: 196, 1938.

After 1909 Howell's efforts as an investigator were devoted almost exclusively to the study of problems in the field of blood physiology and pathology. Of 38 scientific papers published during this period all but 4 dealt with those subjects. Of these subjects it has been said as recently as 1944 that the briefest meditation of the strictly theoretic aspects of the clotting problem leaves one with the appalling feeling that tampering with the coagulability of blood, that protective mechanism of life, par excellence, is a hazardous business. Another worker in this field has said that the subject of blood coagulation now (1945) is in a state of anarchy: "the confused terminology, the multiplicity of hypotheses, the feeling of discomfort would all seem to point to that"; and the same author goes on to say that the clotting problem is difficult "because it is a border-line problem, involving some of the most refractory and least explored substances and reactions."

Howell was fully aware of these difficulties. He realized that the process of clotting involves chemical and physico-chemical reactions among substances whose nature and properties are known only imperfectly, and that a complete explanation of the details of the reactions must await a better comprehension of the chemistry and physical chemistry of the blood. Yet Howell devoted an immense amount of time to efforts to isolate and purify the blood reactants. If he had had available the information which can be and to some extent has been revealed since by the newer methods of analysis, such as electrophoresis, chromatography and supercentrifugation, his progress undoubtedly would have been faster and more certain and fewer revisions of hypotheses would have been necessary. Even so, his contributions have won for him the designation as the great American pioneer of blood coagulation. The frontispiece of the monograph by the Swedish biochemist, Jorpes, dealing with one of the phases of coagulation, is a portrait of Howell, whom he characterizes as "an eminent representative of the series of successful scientists who have advanced America's physiology and medicine to a leading position."

It is quite impossible, within the limits of this sketch, to give an adequate setting for Howell's contributions to this subject.[8] Briefly and categorically, when, in 1909, Howell resumed active interest in this problem, some four or five factors were known to be concerned with the clotting process. To Alexander Schmidt of Dorpat belongs the credit of having contributed to our knowledge of most of them. In papers published between 1861 and 1895 he showed that (1) a soluble blood protein, fibrinogen, is converted into the insoluble fibrin of the clot through the action of (2) thrombin (which he regarded as an enzyme); that the thrombin, however, is not present as such in normal blood but is formed in shed blood from a precursor, (3) prothrombin, through the action of (4) a "zymoplastic substance" secreted, Schmidt thought, by the white cells of the blood. In 1890 Hammarsten and Arthus and Pagés showed independently that (5) calcium plays a role in the conversion of prothrombin into thrombin. It was then found by Spiro and Fuld and by Morawitz, both in 1904, that zymoplastic substance, now generally known as thromboplastin, is derived from disintegrating blood platelets, indeed, from any damaged tissue cells, as in a wound.

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[8] For an excellent summary of the problem of coagulation see Howell's Pasteur Lecture (58).

To this scheme Howell's investigation resulted in the addition of a *sixth factor*. His earliest (1884) work in this field had led him to the correct conclusion that (to use current terms) the normal plasma of terrapin does not contain thromboplastin—the plasma of the carefully drawn blood does not clot unless that factor is added. However, as a result of his 1912 studies he found that mammalian plasma differs from that of other vertebrates in that, as others had maintained before him, it contains within itself an available source of thromboplastin derived, most probably, from constantly disintegrating blood platelets, structures that are not found in the blood of lower vertebrates. Further work at that early date had led him to conclude, as had others before him, that intravascular mammalian blood does not clot, though it contains all of the necessary factors, because of the presence of an "antithrombin." Moreover, he convinced himself that such an "antithrombin" accounts for the incoagulability of drawn blood that results when a solution of peptone is injected into the blood stream of a surviving mammal.

Some three or four years after he had expressed these ideas he assigned to McLean, a second year medical student, the problem of obtaining from heart and liver certain "phosphatides" which were believed to *induce* clotting. In the process a product was isolated, presumed to be a phosphatide, which, instead of inducing clotting, actually *retarded* it. From this point Howell continued the investigation of this anticoagulant, which he named heparin because it was derived in large amounts from the liver. He soon found that it is not a phosphatide, since the purified product proved to be phosphorus-free, that it contains uronic acid, and indications were obtained that sulphur also enters into its composition. Subsequent investigations by others have confirmed all of this and have indicated that heparin is not a chemical individual, but may be a series of different polysulphonic acid esters of mucoitin. Howell succeeded in purifying heparin to the point where 1 milligram prevented the coagulation of 100 milliliters of blood for 24 hours at 0°C. Having demonstrated its presence in normal blood, he early designated it as a "physiological" anticoagulant. Justification for thus regarding it has been supplied through the findings by others that heparin is normally present in certain cells, now called heparincytes, in the walls of blood capillaries whence it can readily gain access to the blood. The incoagulability of the blood in peptone and anaphylactic shocks has been shown to be due to an increase in the amount of heparin formed by the liver. Heparin now is on the market, and is extensively employed to render blood incoagulable in physiological experiments and in the treatment of clinical conditions in which intravascular clotting of the blood is threatened or in process. To quote Jorpes, "Today . . . heparin is as specific in thrombosis as insulin is in diabetes."

Howell worked assiduously and long at efforts to isolate and determine the chemical nature of some of the other then known factors in the coagulation process, but reference can be made to but one other of these attempts. What now is known as thromboplastin had early (Wooldridge, 1886) been regarded as a combination of a protein with the phosphatide, lecithin. Howell's analyses (40) led him to conclude that the phosphatide constituent of thromboplastin is cephalin, not lecithin, and that the thromboplastic activity of the compound is due to the cephalin. His evidence consisted in part in showing that lecithin from several sources has no favoring effect on coagulation whereas he, and subsequently other investigators, found that pure cephalin possesses what was regarded as a high degree of thromboplastic activity. This finding Howell mentions as the third of his discoveries. "I was able to show," he says, "that cephalin is the so-called 'thromboplastic' substance in tissue cells." And he goes on to say that "while this . . . result is not accepted by all workers I am confident that it will prove to be correct."

But before considering Howell's further work with thromboplastin it will be necessary to refer to his protracted studies in hemophilia. His observations on this malady were made possible mainly through the rare opportunity that presented itself of three hemophilic brothers who served as his principal subjects. One of the brothers, Jesse Yaffe, became Howell's faithful laboratory technician—the primary and willing subject of his experiments, which included the testing of a number of so-called remedies mentioned in the literature, all of which proved to be worthless.

The studies on the blood in hemophilia were begun in 1914. In the first paper (43) it was concluded, but with great caution, that "in hemophilic blood *there seems to be* (italics ours) a relative excess of antithrombin owing mainly to an actual diminution in the amount of prothrombin." However, in 1926, after the discovery of heparin, it was found (59) that there is no excess of that anticoagulant in hemophilic blood and that prothrombin is present in normal amounts and possesses normal activity. The blood platelets, however, were found to be more than normally stable, and consequently Howell adopted the view that had previously been suggested by Minot (who at one time had worked in Howell's laboratory) and also by Fanio, that the prolonged clotting time might be the result of a slowing of the liberation of their thromboplastin, a view that still is held in some quarters.

It was in this connection that Howell again became interested in the nature of thromboplastin. He felt that if an homogenous, protein-free thromboplastin could be prepared it might prove to be of value in the control of the hemorrhages of hemophilia. In 1939 he believed he had succeeded in obtaining such a product from lung tissue (70). Lung, it should be added, was the source employed for the reason, among others, that Howell, in 1937, had found that the lung is the organ, par excellence, in which platelets arise (68). But in 1941 (71) he wrote . . . "I have been successful in obtaining from human lung a purified, active preparation . . . but I am not sure at present that it is free of contamination with inactive protein and lipoid constituents." In the meanwhile, Chargaff and Cohn (1940), as a result of analyses by electrophoresis, by supercentrifugation, and by other methods also, concluded that thromboplastin derived from the lung of cattle is a complex molecule made up of proteins and several lipides of which 26% is lecithin and 25% cephalin. This compound, they state, has no thromboplastic activity whatever, after removal of its phosphatides, though the protein-phosphatide compound is

1000 times more active than the total phosphatide fraction. In 1941, Howell says of this work that from the method used in its preparation one may feel uncertain whether this final product is a definite compound.

An account of Howell's last efforts in this quest was published posthumously in 1945. "It was possible", it is stated in that paper, "to remove the protein leaving a residue with marked" and stable "thromboplastic activity, the chemical nature of which has not been determined". The thromboplastic action of the crude material alone had been tested,—the human thromboplastin on a case of aplastic anemia with uncontrollable hemorrhages, "without unfavorable reactions", the pig thromboplastin on a strain of hemophilic pigs with results that "were interesting and suggestive". The question as to whether cephalin is the normal thromboplastic agent, therefore, must still be regarded as unsettled.

Howell, as did most other workers in the field, attempted from time to time to formulate his views on coagulation in the form of "theories". Since, however, reactants in the coagulation process still are being disclosed it is obvious that such statements should rather have been regarded as working hypotheses.

While Howell was engaged in the investigation last mentioned above he was having light heart attacks. On Thursday, February 1, 1945, he had a severer one than usual, and was ordered by his physician to remain at home for a week. In disregard of these instructions, he went to his laboratory on Monday, the 5th. Early Tuesday morning he had a very severe attack and died within a half hour, 14 days before his 85th birthday.

Spirit of Investigation

To the foregoing outline of some of the more significant of Howell's contributions to science should be added a word relative to his views regarding the spirit of investigation and the deportment of investigators. Quotations that reveal his attitude are the following: (1) In Martin's laboratory "the spirit of research was in the atmosphere. There was no pressure of any kind to produce results and there was no expectation that anyone was going to make a great discovery or even an important discovery. The sole animating motive was that we had the privilege of adding something new to the state of physiological knowledge . . ." (F). (2) "In medical research at present" (about 1927) "there is a keen, almost cruel, competition to secure results that will attract attention. It has its good side no doubt in stimulating productivity but it does tend to distort values and set up standards that give to scientific research something of the low motives of commercial warfare" (B). And (3) "Investigators by nature," Howell wrote in 1915, "are men who cannot refrain from following out their ideas. They are driven constantly to such work by interest or by irritation; either stimulus is sufficient. I fancy that among our greatest investigators it is the irritative impulse that predominates." If Howell's persistent attack on the elusive problem of blood coagulation was due to such a drive his mien in the laboratory gave no evidence of it during the six years of the writer's connection with it. At the departmental lunch table, for instance (this was in Howell's private laboratory), he spoke interestingly and freely about the progress of his current experiments. At no time was there a display of more than a quiet enthusiasm, though he was always ready to defend his findings. The same factual, calm discussions are to be found in review articles he wrote on controversial subjects to which he or his students had made contributions. From among these may be mentioned such articles as the Cause of the Heart Beat, the Chemical Regulation of the Processes of the Body by Means of Activators, Kinases and Hormones, Theories of Blood Coagulation, etc. Yet one wonders whether beneath Howell's outward calm there was not concealed this same drive. Howell was not a trained chemist. But when his years were running out he is said to have remarked, "I'd get along faster if I got an expert organic chemist to work with me, but it is more fun to do it myself." As a matter of fact, Howell was chemist enough to determine almost completely the composition of heparin, to recognize cephalin as a thromboplastic agent, and to devise a quantitative test for prothrombin, which, with slight modifications, is a commonly used clinical text today. He could easily have secured the collaboration of a trained chemist and so have speeded his quest. But the drive was there to do it himself.

Textbooks

The first cooperative effort by physiologists of the new world to write a book on physiology for the use of medical students was "An American Textbook of Physiology," published by the W. B. Saunders Company. Howell was the chosen editor of this work. It went through two editions, the first in one volume in 1896, the second in two volumes in 1900. Then, in 1905, Howell wrote his "Textbook of Physiology for Medical Students and Physicians." The preface to the first edition states that the art of presentation makes a textbook successful or unsuccessful and that the guiding principles are simplicity and lucidity in the presentation of facts and theories. This work, issued by the house that published the American textbook, was in its 14th edition at the time of Howell's death, and more than 140,000 copies had been sold. Moreover, after Howell's death the same publishers continued to issue, under other, now joint, authorship, a "Howell's Textbook of Physiology." No better evidence could be given of Howell's ability as a writer of textbooks! It may truly be said that his textbook was the main source of the written lore of physiology for American medical students through a period of 30 to 40 years.

Lectures, etc.

During the Hopkins period Howell delivered a number of formal addresses, many of which have appeared in print. The occasions for these were varied,—natal celebrations of institutions, such, for example, as the 75th anniversary of the founding of the University of Michigan, the 100th of the Yale Medical School, the dedication of the new buildings of the Washington University Medical School, etc. Especially noteworthy are his address on the Problems of Physiology of the Present Time, delivered at the unique, worldwide gathering of talent in connection with the Congress of Arts and Sciences under the auspices of the Louisiana Purchase Exposition, and the presidential address of welcome to the XIIIth International Physiological Congress in Boston. His discussions on these occasions dealt commonly with the historical development of physiology or the role of physiology in relation to science in general and to medical education in particular. Usually his addresses were delivered without notes and always were characterized by a happy choice of sound ideas, logically developed in simple terms. His delivery was unostentatious, his enunciation clear, his voice somewhat high pitched with a quality that was slightly musical.

In addition Howell responded frequently to requests to speak or to write in connection with less formal occasions, some of which were gala, such as presentations of portraits (e.g., Newell Martin's, Florence Sabin's, etc.) and anniversaries (e.g., "William H. Welch at Eighty"), and some memorial, such as obituary notices (e.g., Gilman's, Newell Martin's, Mall's, Abel's, Meltzer's, Finney's). For examples of Howell's superb handling of such topics one should turn to page 80 of "Welch at Eighty" [9] and to the obituary of J. M. T. Finney.[10]

Howell's classroom lectures to the medical students were of the same high quality. They were characterized, moreover, by an entire lack of dogmatism or ostentation; and this was accomplished without concealing his keen interest in the subjects under discussion. Together with his neatly executed experimental demonstrations at the lecture table, his lectures were by common consent an outstanding feature of the four years' course of instruction.

As an Executive

From 1899 until 1911 Howell served as dean of the Medical School in succession to William H. Welch, the first dean. It was during this period that Howell wrote his textbook. Despite these two extra demands on his time he continued as usual to carry the greater part of the formal teaching of the department and to carry on as an investigator. Outwardly he

[9] New York, 1930.

[10] Bull. N. Y. Acad. Med., 18: 552, 1912.

seemed as unperturbed as ever, but during this period he suffered for a time with gastric symptoms. The School prospered during his stewardship as dean. The size of classes on admission, which had been fluctuating around 50, increased to its present limit of 75, and the first additions to the facilities for medical teaching and investigation above those initially obtaining became available. These included the physiological laboratory and a laboratory for surgical research, both on the grounds of the Medical School, and, on the grounds of the Hospital, the Phipps Psychiatric Clinic and the Harriet Lane Home for Invalid Children, additions which made possible the establishment in the School of corresponding teaching and research departments. According to Simon Flexner it was during Howell's deanship that the Advisory Board of the Medical School began the discussions that culminated in the inauguration at Hopkins of so-called full-time clinical teachers and departments.

School of Hygiene and Retirement

Howell must have played an important role in the organization of the School of Hygiene at Johns Hopkins. William H. Welch was the initial director. In 1917 Howell was made assistant director and the following year he resigned his post as professor of physiology in the Medical School in order to accept appointment as professor of physiology in the School of Hygiene. Eight years later he succeeded Welch as the director. It is stated, in a report filed by Howell, that in organizing the School it was intended to restore physiology to the place it had occupied at the time (about 1840) of Pettenkofer in the pre-bacteriological days, as one of the fundamental subjects upon which scientific instruction in hygiene must be based. The first year of Howell's connection with the School was devoted to planning and organization. Teaching and research were begun in 1918 in the old physics building in West Baltimore. Howell gave the course in personal hygiene, a subject that was entirely new to him. His research, however, with but a single excursion into the field of hygiene, continued to deal with factors in blood coagulation. At the beginning the number of students in the school was small. They came to Dr.

Howell's house for Sunday tea and he became very well acquainted with them. They were extremely interesting years (G). After four or five years the School moved to the large new building in the vicinity of the Medical School in East Baltimore. The lecture room of the department of physiology was elaborately equipped for the study of ventilation. Students attending the lectures were required to file daily reports of their sensations of comfort. The analysis of these data formed the basis of a paper entitled "Humidity and Comfort" (66). It led to the conclusion that when provision is made for the removal and movement of air. the dry bulb thermometer is the important standard to maintain.

Howell was created emeritus professor at the age of 71. Then, for one year he served as Chairman of the Medical Division of the National Research Council and for the succeeding year as Chairman of the Council. Thereafter, except for revisings of his textbook, he devoted himself exclusively to research. The University provided him with a laboratory and funds were made available to him at first by the Carnegie Corporation and later from the fluid research fund of the Medical School.

Family Life

The relations between the members of the Howell family were intimate and happy. They quite regularly spent the three summer months on Great Chebeague Island in Maine, where they owned an old farmhouse. There Dr. and Mrs. Howell with their children and, later on, their grandchildren, enjoyed ideal outings. Howell, who previously had taken his exercise mainly in the form of tennis and golf, now took up sailing as his chief summer pastime. When his children became old enough they served as the crew of his 30-foot sloop on cruises along the Maine coast. On these expeditions they, and later on, their children, too, learned from him much more than they learned from their winters in school. The affection and admiration his grandchildren felt for him is evidenced by the fact that each of the then four of them, when in turn required at school to compose an essay on "the person you admire most," chose to write on their grandfather. During his last summers in Maine Howell turned to lawn bowling as his pastime and acquired as great a proficiency at this game as he had throughout his life with all other sports. His age brought no apparent dimming of his mental ability, no decrease in his interest in life, no change in his personality. He never lost his wonderful sense of humor.

In 1887 Howell married Anne Janet Tucker of Baltimore. She predeceased him by some years after a long period of failing health. Their three children are living. Janet Howell Clark, Ph.D., is Dean of the College for Women of the University of Rochester; Roger Howell, Ph.D., is Dean and Professor of Constitutional Law in the University of Maryland and Charlotte Teresa is the wife of Dr. E. O. Hulburt of the Naval Research Laboratory. There are seven grandchildren and, at this writing, two great-grandchildren.

General

Howell was one of the best loved of American physiologists. A kindly disposition and unpretentiousness of manner endeared him to all who knew him well. He held firm but carefully weighed convictions which, however, were never obtruded on casual acquaintances. His strength of intellect, his wisdom, his moral fiber gave him the peace of mind and the sympathetic understanding of his fellow men that were so apparent to all who knew him. He will be remembered not only for his important contributions to physiology, as an inspiring teacher and as an able and considerate administrator, but equally for his fine personal attributes—a calm, simple philosophy of life combined with the strength of character that enabled him to live in the light of that philosophy.

The position he occupied in American physiology is best indicated by the recognition accorded him by his colleagues. He was one of the twenty-eight charter members of the American Physiological Society and read the first paper at the first meeting of that Society. He was its fourth president and was younger by many years than were his predecessors at the time of their incumbency. He was reelected to the office five times, and was a member of the Council of the Society for twenty-two years. He was named chairman of the initial editorial committee of the *American Journal of Physiology* when, in 1914, the American Physiological Society acquired ownership and editorial control of that publication. He was chosen by American physiologists to be the president of the only International Physiological Congress that has met in the Americas. He was editor of "An American Textbook of Physiology," the first cooperative effort of the kind by New World physiologists. He was elected a member of the American Philosophical Society in 1903 and of the National Academy of Sciences in 1905, while relatively young. This is a record no other American physiologist has approached. Yet in his response at a testimonial dinner where his colleagues and students had had the opportunity of expressing verbally their sentiments of love and devotion, Dr. Howell (then approaching his eighty-first birthday) said with characteristic modesty, "there are some visions of the morning that have not been realized, but this happens no doubt to everyone."

Honorary Degrees

M.D., University of Michigan, 1890.

Sc.D., Yale University, 1911.

LL.D., Trinity College (Conn.), 1901; University of Michigan, 1912; Washington University (St. Louis), 1915; University of Edinburgh, 1923.

Other Honors and Memberships in Scientific Societies and Organizations.

Honorary Member, Physiological Society (Great Britain); Honorary Fellow, New York Academy of Medicine; Honorary Member, The Harvey Society, New York; Member of the Executive Committee of Science Service, 1931-42, Chairman and Vice-president; Member National Research Council, Chairman, 1932-33; Prize, American Physiological Society; Member National Academy of Sciences; Member American Philosophical Society; Member American Physiological Society, President, 1905-09; Member Society for Experimental Biology and Medicine; Member Society of Naturalists, President, 1924; Member American Association for the Advancement of Science, Vice-president, Section K, 1908; President International Physiological Congress, 1929.

BIBLIOGRAPHY[11]

SCIENTIFIC PAPERS

1. The influence of changes of arterial pressure upon the pulse rate in the frog and the terrapin. (With M. Warfield) Studies from the Biological Laboratory, Johns Hopk. Univ., 2: 235, 1882.
2. On the effect of variations of arterial pressure on the duration of the systole and the diastole of the heartbeat. (With J. S. Ely) Studies from the Biological Laboratory, Johns Hopk. Univ., 2: 453, 1881-1882.
3. Some observations upon the form of the pulse wave and the mean arterial pressure in a dog with patent ductus arteriosus. (With F. Donaldson, Jr.) Studies from the Biological Laboratory, Johns Hopk. Univ., 2: 381, 1881-1882.
4. Experiments upon the heart of the dog with reference to the maximum volume of blood sent out by the left ventricle in a single beat, and the influence of variations in venous pressure, arterial pressure, and pulse rate upon the work done by the heart. (With F. Donaldson, Jr.) Philos. Trans. Roy. Soc., Lond., Part I, 175: 239, 1884.
5. The new morphological element of the blood. Science, 3: 46, 1884.
6. Notes on the composition of the blood and lymph of the slider terrapin (Pseudemys rugosa). Studies from the Biological Laboratory, Johns Hopk. Univ., 3: 49, 1884.
7. The origin of the fibrin formed in the coagulation of the blood. Studies from the Biological Laboratory, Johns Hopk. Univ., 3: 63, 1884.
8. Observations upon the blood of Limulus polyphimus, Callinectes hastatus and a species of Holothurian. Studies from the Biological Laboratory, Johns Hopk. Univ., 3: 267, 1886.
9. Note on the presence of haemoglobin in the Echinoderms. Studies from the Biological Laboratory, Johns Hopk. Univ., 3: 289, 1886.
10. Note on the specific energy of the nerves of taste. (With J. H. Kastle) Studies from the Biological Laboratory, Johns Hopk. Univ., 4: 13, 1887.
11. Observations upon the occurrence, structure and function of the giant cells of the marrow. J. Morph., 4: 117, 1890.
12. The life history of the formed elements of the blood, especially the red blood corpuscles. J. Morph., 4: 57, 1890.
13. Physiology of the communicating branch between the superior and the inferior laryngeal nerves. (With G. C. Huber) J. Physiol., 12: 5, 1891.

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[11] The abbreviations follow those of the World List of Scientific Periodicals.

14. A physiological, histological and clinical study of the degeneration and regeneration in peripheral nerve fibres after severance of their connection with the nerve centres. (With G. C. Huber) J. Physiol., 13: 335, 1892.
15. A physiological, histological and clinical study of the degeneration and regeneration in peripheral nerve fibres after severance of their connection with the nerve centres, Part III. (With G. C. Huber) J. Physiol., 14: 1, 1893.
16. Action of the inorganic salts of serum, milk, gastric juice, etc., upon the isolated working heart, with remarks upon the causation of the heartbeat. (With E. Cook) J. Physiol., 14: 198, 1893.
17. The effect of stimulation and changes in temperature upon the irritability and conductivity of nerve-fibres. (With S. P. Budgett and E. Leonard) J. Physiol., 16: 298, 1894.
18. The action of oxalate solution on nerve and muscle irritability and rigor mortis. J. Physiol., 16: 476, 1894.
19. A contribution to the physiology of sleep, based upon plethysmographic experiments. J. Exp. Med., 2: 313, 1897.
20. The physiology of internal secretions. Science, 6: 37, 1897. Also Medical News, 70: 655, 1897 and Trans. Congr. Amer. Physicians and Surgeons, 4: 70, 1897.
21. The influence of high arterial pressures upon the blood flow through the brain. Amer. J. Physiol., 1: 57, 1898.
22. The physiological effects of extracts of the hypophysis cerebri and infundibular body. J. Exp. Med., 3: 245, 1898.
23. On the relation of the blood to the automaticity and sequence of the heartbeat. Amer. J. Physiol., 2: 47, 1898.
24. The effect of stimulating various portions of the cortex cerebri, caudate, nucleus, and dura mater upon blood pressures. (With M. F. Austin) Amer. J. Physiol., 3: 22, 1900.
25. An analysis of the influence of the sodium, potassium and calcium salts of the blood on the automatic contraction of the heart muscle. Amer. J. Physiol., 6: 181, 1901.
26. A critical note upon clinical methods of measuring blood pressure. (With C. E. Brush) Proc. Annual Meeting Mass. Med. Soc., 18: 655, 1901.
27. Observations upon the cause of shock, and the effect upon it of injections of sodium carbonate. Contributions to Medical Research, Dedicated to Victor C. Vaughan, Ann Arbor, Mich., p. 51, 1903.
28. The cause of the heartbeat. J. Amer. Med. Assn., 46: 1665 and 1749. Harv. Lect., 8: 305, 1906.
29. Vagus inhibition of the heart in its relation to the inorganic salts of the blood. Amer. J. Physiol., 15: 280, 1906.
30. Note upon the presence of amido acids in the blood and lymph as determined by the β-naphthalinsulphochloride reaction. Amer. J. Physiol., 17: 273, 1906.

31. The proteids of the blood with especial reference to the existence of a noncoagulable proteid. Amer. J. Physiol., 17: 280, 1906.
32. Experiments on the isolated mammalian heart to show the relation of the inorganic salts to the action of the accelerator and inhibitory nerves. (With W. W. Duke) J. Physiol., 35: 131, 1906.
33. The effect of vagus inhibition on the output of potassium from the heart. (With W. W. Duke) Amer. J. Physiol., 21: 51, 1908.
34. Note upon the effect of stimulation of the accelerator nerve upon the calcium, potassium, and nitrogen metabolism of the isolated heart. (With W. W. Duke) Amer. J. Physiol., 23: 174, 1908.
35. The chemical regulation of the processes of the body by means of activators, kinases and hormones. Science, 31: 93, 1910.
36. The coagulation of blood. Cleveland Med. J., 9: 118, 1910.
37. The preparation and properties of thrombin together with observations on antithrombin and prothrombin. Amer. J. Physiol., 26: 453, 1910.
38. The oxidases and other oxygen catalysts concerned in biological oxidations. By J. H. Kastle. (A review) Science, 31: 504, 1910.
39. The role of antithrombin and thromboplastin (thromboplastic substance) in the coagulation of blood. Amer. J. Physiol., 29: 187, 1911.
40. The nature and action of the thromboplastic (zymoplastic) substance of the tissues. Amer. J. Physiol., 31: 1, 1912.
41. The factors concerned in the process of the clotting of blood. Therapeutic Gazette, 36: 95, 1912.
42. Rapid method of preparing thrombin. Amer. J. Physiol., 32: 264, 1913.
43. The condition of the blood in hemophilia, thrombosis and purpura. Arch. Int. Med., 13: 76, 1914.
44. The clotting of blood as seen with the ultramicroscope. Amer. J. Physiol., 35: 143, 1914.
45. Prothrombin. Amer. J. Physiol., 35: 474, 1914.
46. The coagulation of lymph. Amer. J. Physiol., 35: 483, 1914.
47. Note on the effect of temperature upon the action of thrombin and antithrombin. Amer. J. Physiol., 36: 1, 1914.
48. The causes of clotting of blood. Science, 39: 568, 1914.
49. Ultramicroscopic study of the fibrin-gel. Science, 42: 681, 1915.
50. The structure of the fibrin-gel and theories of gel-formation. Amer. J. Physiol., 40: 526, 1916.
51. The coagulation of blood. Harv. Lect. Series 12, p. 272, 1916-17.
52. Two new factors in blood coagulation, heparin and proantithrombin. (With E. Holt.) Amer. J. Physiol., 47: 328, 1918.
53. Note relative a l'action photodynamique de l'hematoporphyrine sur le fibrinogen. Arch. int. Physiol., 18: 269, 1921.

54. Heparin, an anticoagulant. Preliminary Communication. Amer. J. Physiol., 63:434, 1922-23. Proc. Amer. Physiol. Soc. Also Quart. J. Exp. Physiol., Suppl. vol. containing abstracts XIth Int. Physiol. Congr. p. 152, 1923.
55. Physiology of the pituitary gland. J. Amer. Med. Assn., 83:1684, 1924.
56. Inhibition. Physiol. Rev., 5: 161, 1925.
57. The purification of heparin and its presence in blood. Amer. J. Physiol., 71: 553, 1925.
58. The problem of coagulation. Pasteur Lect. Proc. Inst. Med., Chicago, 1935. Also Leopaldina, 4: 13, 1929.
59. Note upon the presence of heparin in normal and hemophilic blood of man. Amer. J. Physiol., 77: 680, 1926.
60. Heparin. Proc. XII Int. Physiol. Congr. Skand. Arch. Physiol., 49: 154, 1926.
61. The cause of the delayed clotting of hemophilic blood. (With E. B. Cekada.) Amer. J. Physiol., 78: 500, 1926.
62. The photodynamic action of hematoporphyrin. (With E. N. Rask.) Amer. J. Physiol., 84: 363, 1928.
63. The purification of heparin and its chemical and physiological reactions. Johns Hopk. Hosp. Bull., 42: 199, 1928.
64. Note on the effect of repeated intravascular injections of heparin. (With C. H. McDonald.) Johns Hopk. Hosp. Bull., 46: 365, 1930.
65. Does hemophilic blood contain an excess of an anticoagulant? (With P. S. Evans, Jr.) Amer. J. Physiol., 98: 131, 1931.
66. Humidity and comfort. Science, 73: 453, 1931.
67. Theories of blood coagulation. Physiol. Rev., 15: 435, 1935.
68. The production of blood-platelets in the lungs. (With D. D. Donahue.) J. Exp. Med., 65: 177, 1937.
69. The effect of defibrination and of peptone injections on the production of blood-platelets in the lungs. Pavlov Memorial Vol., J. Physiol. U.S.S.R., 24: 458, 1938.
70. Hemophilia. The Wesley M. Carpenter Lect. Bull. N. Y. Acad. Med. 2nd series, 15: 3, 1939.
71. Recent advances in the problem of blood coagulation applicable to medicine. J. Amer. Med. Assn., 117: 1059, 1941.
72. The isolation of thromboplastin from lung tissue. (Published posthumously.) Johns Hopk. Hosp. Bull., 76: 295, 1945.

ADDRESSES AND GENERAL PAPERS

73. Instruction in physiology in the medical schools. Michigan Alumnus, 6: 133, 1900.
74. Biology as an element in college training. Address at the opening of the Hall of Natural History, Trinity College. Science, 13: 49, 1901.

75. Problems of physiology of the present time. Congress of Arts and Sciences, Universal Exposition, St. Louis, Vol. 5, 1904.
76. Address at the opening of Le Conte Hall, Biological Laboratory, University of Georgia. Univ. Georgia Bull., 1:23, 1905.
77. Henry Newell Martin. Address at Presentation of His Portrait. Johns Hopk. Univ. Circular, 27:361, 1908.
78. The relation of President Gilman to medical education. Anat. Rec., 3:519, 1909.
79. The medical school as part of the university. (Annual address in Medicine—Yale University.) Science, 30:129, 1909.
80. The so-called sexual necessity in man. Maryland Soc. Social Hygiene, April 17, 1912.
81. Dinner Address—75th Anniversary of University of Michigan. Published by University, 1912.
82. Premedical studies in their relations to general and professional training. Memorial of the Centennial of the Yale Medical School. Yale Univ. Press, p. 45, 1915.
83. Dinner Address—Dedication of New Medical Buildings, Washington University, St. Louis. Published by the University, 1915.
84. Franklin P. Mall. Johns Hopk. Alumni Mag., 6:261, 1918.
85. Third Resuscitation Commission. (Under Auspices of the Commission on Safety Rules and Accident Prevention of National Electric Light Association.) Proceedings and Resolutions. (With Stewart and Thompson.) Long Island Med. J., 13:16, 1919.
86. Dr. Florence R. Sabin—Presentation of her portrait to the University. Johns Hopk. Alumni Mag., 8:253, 1920.
87. Samuel James Meltzer. (Read before Fed. Amer. Soc. Exp. Biol., Chicago, Dec. 28, 1920.) Proc. Soc. Exp. Biol. & Med., 18:25, 1921. Also Science, 53:99, 1921.
88. Scientific research and public health. Trans. Roy. Can. Inst., Vol. 13, 1921.
89. The human machine—How your body functions. The National Health Series, Funk & Wagnalls Co., 1924.
90. Samuel James Meltzer. Memoirs, Nat. Acad. Sciences, Vol. 21, Ninth Memoir, 1927.
91. The relations of public health and medicine—Trimble Lect. Trans. Med. & Chir. Fac. of Maryland for 1925-1929, p. 213, 1927.
92. The medical side of animal experimentation—Statement in regard to the experimental use of dogs in the promotion of medical research. Issued by the Committee for the Defense of Medical Research, Med. & Chir. Fac. of Maryland, 1928.
93. Dr. Charles E. Simon. Amer. J. Hyg., 8:1, 1928.
94. Address of welcome. The XIIIth International Physiological Congress. Science, 70:199, 1929.

95. A statement of facts in reference to an accusation of cruelty made by the National Anti-Vivisection Society. (Dr. Howell's answer to a published statement by Mr. C. E. Richards.) Living Tissue, 15: 5, 1930.
96. Tribute to William H. Welch at the University Club reception. William Henry Welch at Eighty. p. 80, New York, 1930.
97. The development of physiology during the past twenty-five years and Dr. Cannon's influence upon it. (Given at the exercises held October 15, 1931.) Walter Bradford Cannon 1906-1931. Harvard Univ. Press, p. 26, 1932.
98. Hurry and health. (Radio talk under joint auspices of the City Health Department and the Med. & Chir. Fac. of Maryland.) Baltimore Health News, 2: 148, 1935.
99. The American Physiological Society during its first twenty-five years. History of the Amer. Physiol. Soc. Semicentennial, 1887-1937, p. 1, 1938.
100. John Jacob Abel. Amer. Phil. Soc. Yearbook, 1938, p. 355, 1939.
101. Foreword to the Chronicle of the Johns Hopk. Hosp. and Johns Hopk. Univ. School of Med. Vol. I, 1867-1893. By Alan M. Chesney. Johns Hopk. Press, p. v, 1943.
102. John Miller Turpin Finney. Bull. N. Y. Acad. Med., 15: 552, 1942.

BOOKS AND SECTIONS OF BOOKS

"Dissection of the dog as a basis for the study of physiology." H. Holt & Co., 1888.

"An American text-book of physiology." By W. H. Howell and Associates, edited by W. H. Howell. Two editions. W. B. Saunders Co., 1896 and 1900.

"Text-book of physiology for medical students and physicians." Fourteen editions. W. B. Saunders Co., 1905 to 1940.

"Eugenics as viewed by the physiologist." (Lecture delivered at the Johns Hopkins University, February 27, 1913.) "Eugenics, twelve University lectures," Chapter IV, p. 78. Dodd, Mead & Co., 1914.

Sections of "Reference handbook of medical sciences." Includes physiological theories of death; physiology of secretion; histology and physiology of the spleen; segmentation of the ovum. William Wood & Co., 1889-1917.

H. F. Blichfeldt.

HANS FREDERIK BLICHFELDT

1873–1945

BY E. T. BELL

Hans Frederik Blichfeldt was born on January 9, 1873, in the village of Iller, Denmark. His father was a farmer, who emigrated to the United States in 1888. His mother, Nielsine Marie Schlaper, was a widow of 31 when she married Hans' father. By her first marriage there was one son, by her second, one son, Hans, and two daughters. Till 1881 the family lived on a farm, when it moved to Copenhagen. "Though not actually poverty-stricken," according to Blichfeldt, "the family had to live very frugally; we children had to work to help out during our earlier years." The genealogy of that branch of the Blichfeldt family to which Hans belonged has been traced back from 1910 to 1540. Nearly all the men in the family and some of the women lived to an advanced age. His immediate ancestors were farmers, who had received their education in the Danish public schools. In the Denmark of their day there was but little opportunity for a strong and ambitious young man to advance beyond the hard labor for which he was naturally fitted by a sturdy physique. The brains in the family seem to have come from a long line—about 300 years—of ministers. Emigration to the United States gave young Blichfeldt the opportunity he probably would not have had in his native land, in spite of his demonstrated mathematical ability in the public schools.

Blichfeldt discovered his mathematical talent before he was fifteen, when he found for himself the solutions of the general algebraic equations of the third and fourth degrees. Even with all the advantages of modern notation, this was no small achievement, as anyone familiar with the history of algebra, particularly in the Sixteenth Century, will agree. Throughout his school career, Blichfeldt stood far out in front of his classmates in mathematics, gaining the highest honors in the "general preliminary examination," a Danish State examination held at the University. Part of this success he owed to his father's teaching. In languages he was handicapped by a poor memory for foreign words, aggravated by the fact that he could not afford to buy dictionaries. Later, on coming to the United

States, he mastered English—or American—and spoke with only a slight accent.

The sturdy, hardy immigrant boy quickly found employment as a farm laborer or worker in sawmills in Nebraska, Wyoming, Oregon and Washington. This phase lasted till 1892, when Blichfeldt was nineteen. He then got jobs with engineering firms for two years. All in all he crisscrossed the country "from East to West, from North to South, and back again" several times. One of his jobs was with a surveyors' party in the roughest sections of San Bernardino County, California. Apparently it was this engineering experience from 1892 to 1894 that was the turning point in his life. Years ago there was a legend at Stanford that Blichfeldt got his chance when he astonished the surveyors by doing in his head the calculations for which they required pencil and paper and mathematical tables. Like all legends, this one may have grown beyond fact with the passage of time, but there was nevertheless a good deal in it. Blichfeldt knew from his Danish school career that he had more than ordinary mathematical ability. His feats of mental calculation convinced the engineers that here was a real mathematician going to waste on tasks far below his capacity. They urged him to apply for admission to Stanford University, then only about six years old.

Blichfeldt was admitted in September, 1894, and by June 1896 had his A.B. degree; by June 1897, his A.M. At the time, there were no tuition fees at Stanford, and the "free elective system," adapted from Harvard, gave a student who knew where he wanted to go a chance to get there quickly. As Blichfeldt with the frugality and thrift characteristic of his family had saved a substantial part of his wages, he had no trouble with living expenses during his three years as a student at Stanford. He did not have to take odd jobs, as so many did, to pay his way. He gained some experience as a teacher in his year (1896-97) as a teaching assistant in mathematics. With the exceptions noted presently, the rest of his academic career was passed at Stanford: Instructor (in mathematics), 1898-1901; Assistant Professor, 1901-06; Associate Professor, 1906-1913; Professor, 1913-1938; Head of Department, 1927-1938; Emeritus, 1938 till his death in 1945. The Stanford experience was supplemented by teaching in the summer session of 1913 at the University of Chicago, and the like at Columbia University in 1925 and 1926. More important than these interludes, when Blichfeldt was an established mathematician, was an earlier one.

In the 1890's it was still the custom, inherited from the 1880's, for aspiring young mathematicians to go to Germany for advanced instruction in what were then the subjects of living interest. Germany led the mathematical world, and to the competence in modern mathematics which ambitious young American mathematicians acquired from the German masters, the United States owes its sudden emergence as a mathematical state able to hold its own. Blichfeldt decided to go to Germany for a year's study.

The outstanding mathematicians working in the Germany of the late 1890's were Sophus Lie (Norwegian, 1842-1899), Felix Klein (German, 1849-1925), and David Hilbert (German, 1862-1943). Lie was at Leipzig, Klein at Göttingen. Possibly because Lie was a fellow Scandinavian, Blichfeldt chose him. Hilbert was still on his way to the top and absorbed in his own researches. Moreover, he seems to have been somewhat unapproachable, especially to Americans. Klein, as the consequence of a nervous breakdown from overwork, had passed his peak. Nevertheless, as Blichfeldt said many years after his sojourn in Germany, "Klein was the daddy of them all"—a judgment, however, in which few today would concur. Blichfeldt spent his year with Lie, mastering the "Lie theory" of continuous groups as it then was. At the end of the year (1898) he was awarded the Ph.D. degree from the University of Leipzig, *Summa cum laude*. With the death of Lie (1899) interest in the Lie theory waned, and Blichfeldt gave it up as a main interest not long after his return to Stanford. One detail of his year in Germany should be recorded. In spite of all his thrift, Blichfeldt lacked sufficient funds to go abroad. Professor Rufus Lot Green of Stanford loaned him the necessary money. For this generosity, Blichfeldt was always grateful, and he repaid it in more ways than one. When he had earned an international reputation as a mathematician, Blichfeldt made many trips to Europe, renewing old friendships with some of the prominent European mathematicians.

Blichfeldt never married. The family ties were very close, and what he could spare went to help his relatives. His mother died in 1912 at the age of 81, his father in 1922 at 84.

In describing his father, Blichfeldt said he was "energetic, frugal, generous; he lived very simply and worked very hard all his life." He also said that his father had failed to accumulate a competence for his old age because "he trusted people"—the obverse side of generosity. In his last years the father lived with his son in a large, old-fashioned but comfortable house with a fine garden crammed with plants, many of them more suitable for lush Denmark than semi-arid California.

One of Blichfeldt's personal characteristics in middle life seems to have been the direct outcome of his early years of hard physical work and enforced frugality. The tall, strong man was physically too robust for the cramping routine of academic life and the sedentary business of mathematical research. He indulged in whatever exercise was popular—hiking, bicycling, swimming, motoring—but it was not enough, and he became a confirmed hypochondriac. Neither his friends nor his physicians could see anything the matter with him, except possibly a tendency to take things too easy. Check after check by specialists here and abroad resulted only in unnecessary expense. His complaints invariably proved to be imaginary, and his less sympathetic friends lost patience. But they soon got over their spells of exasperation, for Blichfeldt was a kind, generous and likable man. When he achieved a moderate prosperity, he shared with his friends all the good things he had missed as a young man and could now afford. He died at the age of 72, not of the heart disease he had imagined for forty years, but as the result of an operation.

Among his distinctions were the vice-presidency of the American Mathematical Society, 1912; member of the National Academy of Sciences since 1920; membership in the National Research Council, 1924-27; and Knight of the Order of Dannebrog (Denmark) 1939.

Blichfeldt's mathematical output was not voluminous, and although what he himself considered his main contributions (Nos. 7, 10, 19 in the bibliography) are impressive, it cannot be said that his publications give a just estimate of his potentialities. He attacked difficult problems, many of them important in the mathematics of his day, disposed of some, but left many more incomplete—"I never finish things." After he had seen through some problem to its end, too often the drudgery of reducing his notes to printable form was too repulsive for him to undertake, and—as a competent expert said—Blichfeldt left behind him "a barrel of good stuff." This barrel is unlikely to be tapped now; mathematical tastes have changed since the good stuff was laid down. In the late 1920's, for instance, Blichfeldt had a sudden outburst of activity in the structure theory of algebras, and for several weeks sent at least one special delivery letter a day to his algebraic friends announcing his latest finds. But, with the end in sight, he lost interest, and possibly all that he did is now more simply done in the manner of modern abstract algebra.

Brief descriptions of the material in some of the papers listed in the bibliography follow:

No. 1. This gives explicit determinations for the sides of all triangles described in the title. It was Blichfeldt's first paper.

No. 2. An investigation of the class of all finite continuous groups of n-space having not less than $m > 1$ invariant points, while all invariants of $s > m$ points are expressible in terms of the invariants of the system of m points which are a subset of the system of s points. For 3-space and $m = 2$, Lie discussed this problem in connection with his researches in the foundations of geometry. Blichfeldt extended this to $m = 3$, finding 8-, 7-, and 6-parameter groups according as the number of independent invariants for 3 points is 1, 2, or 3.

No. 3. This paper introduced a new method for the determination in question. The leading idea is that a group of point-transformations in the plane, in more than two parameters, leaves invariant at least one differential equation which is integral and algebraic in the derivatives.

No. 4. This belongs to an extensive department of approximate analysis originated by Tchebycheff. As an application, Blichfeldt finds as the greatest approximation to $\sin x$ in the form $a_1x + a_2$, in the interval $0<x<h<\pi/2$ the value

$$\frac{\sin h}{h}x+\tfrac{1}{2}\left[1-\left(\frac{\sin h}{h}\right)^2\right]^{1/2}-\frac{\sin h}{2h}\cos^{-1}\left(\frac{\sin h}{h}\right).$$

No. 5. A rigorous elementary proof, independent of the parallel axiom, of the famous theorem on the angle-bisectors.

No. 6. In n-space the distance between two arbitrary points is expressed as an algebraic function of their distances from a set of fixed points. It is postulated that a "distance-relation" exists between the mutual distances of $n + 2$ points.

No. 7. A specimen theorem must suffice. In every finite group of linear homogeneous substitutions on the n-variables, those substitutions whose orders are divisible only by primes greater than $(n-1)$ $(2n + 1)$, form a subgroup. The theory of group characters is used.

No. 8. A continuation of No. 6. An application determines all surfaces having a distance-relation between 5 arbitrary points with the property that between their rectilinear or geodesic distances two or more relations hold.

No. 9. Gives a characteristic invariant for central conics.

No. 10. Continuation of No. 7.

No. 11. One of the applications proves Frobenius' theorem that if the order of a group is divisible by n, then the number of those elements of the group whose orders divide n is a multiple of n.

No. 12. New proof and generalization of C. Jordan's fundamental theorem on finite groups of linear homogeneous substitutions in n-variables and their abelian subgroups.

No. 13. A complete determination.

No. 14. Continuation of Nos. 7, 10.

No. 15. This recognizes the importance of Galois fields in studies of representations of finite groups as groups of linear homogeneous substitutions.

No. 16. Application of the methods developed in Nos. 7, 10 to the complete determination of the groups in question.

No. 17. Extensions, with proofs of several theorems (1901) of Frobenius.

No. 18. Continuation of Nos. 7, 10, 14.

No. 19. This refers to what, after Minkowski is called the geometry of numbers, and it is here a question of trapping lattice points in n-dimensional continua by translations of the coordinate system. For an exact description, the paper itself must be consulted. One theorem is comprehensible without elaboration: Let F be a positive definite quadratic form of determinant D. Then integers $l_1, \ldots, l_n$, not all zero, may be substituted for the n variables such that the numerical value of F is not greater than

$$\frac{2}{\pi}\left[\Gamma\left(1+\frac{n+2}{2}\right)\right]^{2/n} D^{1/n},$$

where Γ indicates the usual gamma function. Asymptotically the value of this expression is $nD^{1/n}/2\pi e$, which is one half of that obtained by Minkowski.— This paper started Blichfeldt on a long series of researches on the minima of quadratic forms; the theorem cited is an example.

No. 20. Blichfeldt's section of this useful text was clearly and attractively written.

No. 21. A systematic treatise containing some of the author's original work.

No. 22. Too brief to be of much interest either as history or exposition. The promised amplied exposition evidently was abandoned, as it never appeared.

No. 23. This is the direction of approximations to linear functions, with rational coefficients, of linearly independent irrational numbers, of which the first example was given by Liouville. Blichfeldt approximates simultaneously to n linear forms of a special type.

No. 24. This is a sequel to No. 19. The minimum of a positive definite quadratic form in n variables with given determinant D is $\leq \gamma n\, D^{1/n}$, where γn depends only on n. Blichfeldt had obtained on upper limit for γn which he here sharpens.

No. 25. Explicit minima $\left(\frac{64}{3}\right)^{\frac{1}{6}}$, $(64)^{\frac{1}{7}}$, 2 respectively for the forms named in the title.

No. 26. A considerable generalization of certain work of Minkowski on a similar topic.

No. 27. Sufficiently described by the title.

BIBLIOGRAPHY

1. Triangles with rational sides having rational areas. Annals Math., vol. 7, 1896, pp. 57-60.
2. On a certain class of groups of transformation in space of three dimensions. Amer. Journ. Math., vol. 22, 1900, pp. 113-120.
3. A new determination of the primitive continuous groups in two variables. Trans. Amer. Math. Soc., vol. 2, 1901, pp. 249-258.
4. Note on the functions of the form

$$f(x) = \phi(x) + a_1 x^{n-1} + a_2 x^{n-2} + \ldots + a_n$$

which in a given interval differs the least possible from zero. Trans. Amer. Math. Soc., vol. 2, 1901, pp. 100-102.

5. Proof of a theorem concerning isosceles triangles. Annals Math., ser. 2, vol. 4, 1902, pp. 22-24.
6. On the determination of the distance between two points in space of m dimensions. Trans. Amer. Math. Soc., vol. 3, 1902, pp. 467-481.
7. On the order of linear homogeneous groups. Trans. Amer. Math. Soc., vol. 4, 1903, pp. 387-397.
8. On the functions representing distances and analogous functions. Amer. Journ. Math., vol. 25, 1903, pp. 331-348.
9. Note on a property of the conic sections. Bull. Amer. Math. Soc., vol. 9, 1903, pp. 306-7.
10. On the order of linear homogeneous groups; second paper. Trans. Amer. Math. Soc., vol. 5, 1904, pp. 310-325.
11. A theorem concerning the invariants of linear homogeneous groups, with some applications to substitution groups. Trans. Amer. Math. Soc., vol. 5, 1904, pp. 461-466.
12. On primitive linear homogeneous groups. Trans. Amer. Math. Soc., vol. 6, 1905, pp. 230-236.
13. The finite discontinuous primitive groups of collineations in four variables. Math. Annalen, Bd. 60, 1905, pp. 204-231.
14. On the order of linear homogeneous groups; supplement. Trans. Amer. Math. Soc., vol. 7, 1906, pp. 523-529.
15. On modular groups isomorphic with a given linear group. Trans. Amer. Math. Soc., vol. 8, 1907, pp. 30-32.
16. The finite discontinuous, primitive groups of collineations in three variables. Math. Annalen, Bd. 63, 1907, pp. 552-572.
17. Theorems on simple groups. Trans. Amer. Math. Soc., vol. 11, 1910, pp. 1-14.
18. On the order of linear homogeneous groups. Fourth memoir. Trans. Amer. Math. Soc., vol. 12, 1911, pp. 39-42.
19. A new principle in the geometry of numbers, with some applications. Trans. Amer. Math. Soc., vol. 15, 1914, pp. 227-235.
20. Finite groups of linear homogeneous transformations. Part 2 of textbook on Theory and Application of Finite Groups, by G. A. Miller,

H. F. Blichfeldt, and L. E. Dickson. New York, John Wiley & Sons; London, Chapman & Hall, 1916, pp. 17-390.

21. Finite Collineation Groups. University of Chicago science series, Chicago, 1917, pp. 1-194.
22. Report on the Theory of the Geometry of Numbers. Bull. Amer. Math. Soc., vol. 25, 1919, pp. 449-53.
23. On the approximate solution in integers of a set of linear equations. Proc. Nat. Acad. Sci., vol. 7, 1921, pp. 317-19.
24. The minimum value of quadratic forms, and the closest packing of spheres. Math. Annalen, Bd. 101, 1929, pp. 605-8.
25. The minimum values of positive quadratic forms in six, seven and eight variables. Math. Zeit., Bd. 39, 1934, pp. 1-15.
26. A new upper bound to the minimum value of the sum of linear homogeneous forms. Monatshefte für Mathematik und Physik, Bd. 43, 1936, pp. 410-14.
27. Note on the minimum value of the discriminant of an algebraic field. Monatshefte für Mathematik und Physik, Bd. 48, 1939, pp. 531-33.

James R. Angell

JAMES ROWLAND ANGELL

1869–1949

BY W. S. HUNTER

The death of James Rowland Angell at Hamden, Connecticut, on March 4, 1949, marked the passing of another of the great figures who shaped the development of American psychology during the formative years when the young science was beginning to expand and to gain extensive academic recognition. Angell came into psychology with a philosophical background which made him particularly sensitive to the general issues that needed discussion and decision as a basis for a sound and fruitful development of psychology. He participated vigorously in the development of the new psychology laboratory at the University of Chicago. He contributed several particularly brilliant analyses of contemporary theoretical problems. Following twenty-five years of work as a psychologist and an administrator at Chicago, Angell went on with outstanding success to become Chairman of the National Research Council, President of the Carnegie Foundation, and President of Yale University. In this last position, he was able to add greatly to the effectiveness of psychology through the establishment at Yale of the Institute of Psychology which later became the Institute of Human Relations. Other high honors came to Angell, but he will be remembered in psychology primarily for his championship of biological functionalism and for his administrative genius in aiding the growth of the science.

Angell was born, the youngest of three children, in Burlington, Vermont, on May 8, 1869, the son of James Burrill Angell and Sarah Caswell Angell. His mother was the daughter of Alexis Caswell (1799-1877) who was graduated from Brown University in 1822 and then, after a brief career as a Baptist minister, became professor of mathematics (1828-63) and subsequently president (1868-72) of that institution. Caswell was also one of the original incorporators of the National Academy of Sciences in 1863, serving for a time as its secretary. James Burrill Angell, the father (1829-1916), was graduated from Brown University in 1849; married Sarah Caswell in 1855; chose the professorship of modern languages at Brown when offered the choice of this position or that of professor of civil engineering and served in the chosen chair from 1853 to 1860; served as editor of the *Providence Journal* during the Civil War years (1860-66); was the president of the University of Vermont from 1866 to 1871; and from 1871 to 1909 was president of the University of Michigan. During the years 1880 to 1882 he was United States Minister to China, and in 1897-1898 he occupied a similar post in Turkey. Other than those above mentioned, the Angell forebears were of sturdy but undistinguished stock descended from Thomas Angell who accompanied Roger Williams into the future Colony of Rhode Island and Providence Plantations in 1636. Frank Angell was a cousin who became professor of psychology at Cornell, before Titchener, and then professor at Stanford University. James Angell's only brother, Alexis Caswell Angell, was a distinguished lawyer in Michigan, and his only son, James Waterhouse Angell, is a professor of economics at Columbia.

Life as the youngest child in the family of James Burrill Angell was undoubtedly an education in itself as a result of contacts with distinguished visitors and the privilege of several years in Peking and Constantinople. Angell's early formal education was in the public schools of Ann Arbor and in the University of Michigan where he was graduated in 1890. Through high school and college he followed the classics curriculum. The only science that he studied was botany; general biology was not offered and the courses in physics and chemistry could not well be fitted into the classical course. Courses in logic and psychology however were available and these he seems to have elected enthusiastically. John Dewey, who had been graduated at Vermont in 1879, after the Angell family had left, had become a professor of philosophy at Michigan (1889-1894). Dewey's textbook on psychology (1886), the first American volume devoted to the new science, was the initial source of Angell's interest in the field, supported by some work in the history of philosophy under James Hayden Tufts. (Both Tufts and Dewey were later to be Angell's colleagues at Chicago.) The academic year 1890-91 was spent at Michigan working for a master's degree with philosophy as the major field and economics and history as minors. Angell's thesis topic was "imagery," a subject on which he was later to make an important contribution through a report on methodology to the American Psychological Association in 1910. The year

1890 saw the publication of William James' *Principles of Psychology,* and it is not surprising that Dewey offered a seminar on the subject or that young Angell was a member of the group which enthusiastically canvassed the field of the new science so extraordinarily presented by James. For the duration of Angell's life, the fundamental principles and the point of view laid down by James were to be of the greatest possible influence on his psychological thinking.

Angell was now definitely committed to a career in psychology. He had previously decided not to enter medicine because of a tormenting weakness of his eyes and the handicap which this would offer in laboratory work. The year 1891-92 was spent in graduate work at Harvard under James where the most impressive work to Angell seems to have been in abnormal psychology and psychical research, the latter an area in which James was at that time particularly interested. Concerning this period, Angell has written as follows: ". . . it also put me in direct contact with one of the most inspiring and beautiful human beings I have ever known. If the result was not important for psychic research, it was of the utmost importance for my development and my devotion to a noble person whose friendship was warm and intimate as long as he lived." [1]

After receiving his master's degree at Harvard in 1892, Angell decided not to accept the department's offer to remain as a laboratory assistant to Herbert Nichols but to seek his doctor's degree in Germany. It is interesting that Angell did not work in Leipzig with Wundt who was the world's foremost psychologist and champion of an experimental approach to the field, having founded the first laboratory of psychology in 1879. Leipzig had been the mecca for many other American students including G. Stanley Hall, James McKeen Cattell, and Angell's cousin Frank Angell. However, the laboratory space with Wundt was full, and since Wundt's lectures were based on his *Grundzüge der physiologische Psychologie,* which Angell had already mastered, he went on to Berlin to study with Ebbinghaus and Paulsen. For the second semester, he transferred to Halle for study with Benno Erdmann and Hans Vaihinger. At Halle he became a candidate for the doctor's degree presenting a thesis on the treatment of freedom in Kant's philosophy. With his thesis accepted, contingent upon revision to improve its German, Angell was confronted with a formidable personal problem, the choice of remaining in Germany to complete his work for the doctorate or of accepting an instructorship at the University of Minnesota. The salary involved was $1500, adequate however to enable him to marry Marion Watrous of Des Moines, Iowa, whom he had known as a fellow student at Michigan. Angell (now 24 years old) decided to accept the Minnesota offer. Although he was later to receive many honorary degrees and although he supervised the doctoral work of many graduate students, he never returned to Halle for his own degree in course.

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[1] James Rowland Angell: Autobiography. (Ch. 1 in *History of Psychology in Autobiography,* V. 3.) Worcester: Clark University Press, 1936. p. 7. The present author well recalls the memorial meeting for William James held by the Psychology Department at Chicago in the fall of 1910 when Angell paid moving tribute to the personality and genius of James.

One year was spent as an instructor in Minnesota. In 1894 John Dewey, the newly appointed professor of philosophy at the University of Chicago, brought Angell there as an assistant professor in charge of psychology. For the next twenty-five years Angell was to devote his energies to this University, the first fourteen years exclusively to psychology and the last eleven years to an increasing absorption in administrative duties. Angell waited seven years (until 1901) for his first promotion to an associate professorship; and then in 1903, as a result of an offer of a professorship at Princeton, he was promoted to top rank at Chicago. A further gain came from this in 1904, when psychology was made a department separate from philosophy with Angell as chairman. The presidency of Dartmouth College was offered him in 1908. Although he refused it, he accepted the Deanship of the Senior College at Chicago. In 1911, he became Dean of the Faculties and Acting President in 1918-19. Concerning this shift of interest from psychology to administration, Angell has written as follows: "Although I kept up a considerable part of my teaching and continued active supervision of the laboratory and the research program of the department, the division of attention was inevitable and, as so often happens to university men, the administrative work increasingly encroached on the work of the scholar. . . . I have only myself to thank for the outcome, as I could at any time, in the earlier years at least, have turned back. The only element of the situation which gives me permanent distress is that so often the controlling motive in the early stages of the change was financial. Salaries were small, the costs of living high, my family growing. . . . Indeed throughout almost all of my career at Chicago, I was obliged to add to my normal salary by every available means—by teaching in the summer, by teaching university extension courses, by lecturing before clubs, and by teaching in local institutions in the late afternoons, at night, or on Saturdays." [2]

In 1914 Angell was chosen as Exchange Professor at the Sorbonne; but due to the outbreak of war, he never occupied the post. He was however intimately connected with some aspects of military psychology in this country during 1917-18 as a member of the Committee on Classification of Personnel advisory to the Adjutant General's Office and as a member of the Committee on Education and Special Training which sought to integrate the military and civilian training programs largely through the establishment of the Student Army Training Corps. At the close of the war, Angell succeeded John C. Merriam as chairman of the National Research Council, having been given leave of absence from Chicago for 1919-20. This was not only the year when many of the post-war decisions influencing the future development of the Council were made but the year in which the architectural planning for the new National Academy of Sciences building was accomplished and in which considerable sums of money were raised. In this situation, Angell played an important role. He was greatly stimulated by the problems which he met and by the men with whom he was associated, so much so that he regarded the year as one of the most fruitful periods of his life.

The winter of 1920 brought an invitation to become President of the Carnegie Corporation. Such a move would inevitably mean the breaking of academic ties and the embarking on a new type of career, a difficult task for one who had spent his entire life in universities and who was now 51 years old. However, the situation at Chicago was not encouraging and the decision to accept the Carnegie offer was made. Angell had received numerous offers of university presidencies, including one from Michigan. Members of the Board of Trustees at Chicago had expressed the wish that he become president of Chicago when that position became available, but that was at some indefinite time in the future. As Angell wrote, "In any case, however, promotion there [Chicago] was, for the time being at least, blocked and my frequent invitations to other positions of consequence kept my status more or less an active subject of comment and discussion in the University community. All this had created a situation which I felt to be a little uncomfortable."[3]

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[2] Autobiog., p. 15.

Within a year after accepting the Carnegie post, Angell had to make another difficult decision. He was offered and accepted the presidency of Yale University. This enabled him to return to the congenial conditions of academic life, but it placed him, a man of essentially mid-western outlook in spite of his Rhode Island ancestors, in the position of being the first non-Yale man to be elected to the presidency of that institution. That he had great misgivings concerning the degree to which he could enlist the sympathetic support of the Yale community is certain. That these misgivings were also in part borne out by experience is also clear. Comments in his *Autobiography* can fairly be interpreted as indicating an ambivalent attitude toward the Yale experience. Thus in discussing his refusal in 1908 of the presidency of a New England college, Dartmouth, he says: ". . . I declined the appointment and my subsequent experiences at Yale have confirmed my feeling that the decision was eminently wise."[4] About the Yale decision, he wrote: "In any case, I went and while I have had some dark days, on the whole my life has been very happy. If I have not done all I had hoped, I have at least had fewer obvious failures to regret than I might reasonably have expected."[5] These comments should not be taken to indicate that Angell did not have widespread and increasing support from the friends and members of Yale. Under his administration, Yale carried out a great building program, significantly strengthened its faculty, and particularly (from the standpoint of Angell, the psychologist) established an Institute of Psychology in 1924 with the financial aid of the Laura Spelman Rockefeller Memorial.

The idea of an Institute for cooperative research probably grew largely out of Angell's experience with the National Research Council. From 1922 to 1924, he discussed the problem with R. M. Yerkes and others seeking a feasible plan by which psychobiological, biological, and anthropological research could be integrated. When the Institute was established, the three major appointments were R. M. Yerkes (for research in psychobiology and primate biology), Raymond Dodge (for research in physiological psychology), and Clark Wissler (for research in racial psychology). In the years that immediately followed, influences were at work at Yale which were to lead Angell to propose an even more comprehensive attack on the problems of human behavior. Experience with the Institute had been favorable. The School of Medicine was expanded and strengthened particularly in the field of psychiatry. The Child Development Clinic under Arnold Gesell was also a part of the picture. It therefore resulted that an enlarged plan was drawn for an Institute of Human Relations to include psychology, primate biology, research and clinical psychiatry, child development, and social science. Funds for a building and for a ten-year research program, totaling $4,500,000, were secured from the Rockefeller Foundation and the General Education Board. By the fall of 1931, the Institute of Human Relations was a going concern. In the Report of the President of Yale University, 1928-29, while the plan was maturing, Angell wrote as follows: "The Institute is designed to achieve two principal ends: first, to carry on research upon the basic problems of human nature and the social order; and second, to train a skilled personnel for work in these fields. Undoubtedly a large part of the most fruitful and significant research must be cooperative in character, and the Institute is so organized as to render this result easy and natural. Crime, poverty, disease, human unhappiness in its manifold forms, cannot be thoroughly understood, much less mitigated and ultimately prevented, without the convergence of many forms of science and technologies, or skills, which are commonly conducted in separation, if not in complete isolation. Biology, psychology, medicine, law, social science, to mention but a few of the related disciplines, are all involved. . . . Prevention, at which we always aim where possible, is obviously impractical, except where there is such opportunity for fundamental understanding of the causative facts."[6] The successful promotion and guidance of this Institute constituted one of

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[3] Autobiog., p. 19.
[4] Autobiog., p. 14.
[5] Autobiog., p. 20.

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[6] Bull. Yale Univ., Feb. 1, 1930, pp. 5-6.

Angell's great contributions to science and to psychology in particular.

The portion of Angell's career when he was a productive scientist and an immensely stimulating teacher lies between 1894 and about 1912-14, a period when he ranged from 25 to 45 years of age. During this time he raised the status of psychology at Chicago from essentially zero to a rank equal to that of the best three or four departments in the country. Chicago became known for its broad and catholic investigations of all aspects of the human psychophysiological organism. It did not limit itself to the structural analysis of consciousness as did its important rival, Cornell, where Titchener had led psychology since 1892. Graduate students were encouraged to minor in biology, philosophy, or education. H. H. Donaldson, A. J. Carlson, and C. Judson Herrick in biology, J. H. Tufts, A. W. Moore, E. S. Ames, and G. H. Mead in philosophy, C. H. Judd, W. F. Dearborn, and F. N. Freeman in education were all cooperative with Angell's effort to make psychology at Chicago a fruitful science. Through the year 1917, something over 40 doctor's degrees were awarded in the field based on theses on such varied subjects as the following: sex differences in mental traits, the psychology of meaning, animal behavior, volition, imagery, hearing, vision, social psychology, tests, memory and learning, space perception, and systematic theory. Practically without exception, they were theses based on extensive experimental work. The one outstanding theoretical paper was written by Carl Rahn on the place of sensation in contemporary theory. This study, guided and criticized by Angell, leveled such a devastating criticism at the doctrine of elements and attributes that a major modification of Titchener's structural psychology was required. To call only a partial roll of the psychologists who took their doctor's degrees at Chicago during Angell's tenure will suffice to remind the psychological reader of the importance of Chicago in the development of the science in this country: Helen T. Woolley, Kate Gordon, John B. Watson, Harvey Carr, Grace Fernald, Joseph Peterson, June Downey, W. V. Bingham, C. S. Yoakum, Carl Rahn, Stella Vincent, Ellsworth Faris, E. S. Robinson, Beardsley Ruml, and L. L. Thurstone.

In the departmental development which has been sketched above, Angell had of course the cooperation of his colleagues in psychology, particularly of John B. Watson from 1903 to 1908 and of Harvey Carr after 1908, his own students and two of the best experimental psychologists that America has produced. It was Angell's leadership, however, which supplied the guiding thread of unity to the growing department. In addition to this and to the general, sometimes specific, guidance of research, Angell was contributing something novel in American psychology, systematic seminars on the history of German, French, and American psychology devoted primarily to the analysis of theories and concepts. Angell's own experimental research was concerned with reaction time as a function of attention, space perception, imagery, the monaural localization of sound (with himself as subject since he had been deaf in one ear from childhood), and the relation of organic processes to consciousness. All of this work involved both objective data and introspective reports from the subjects, although the introspections were never of the Titchenerian element and attribute type.

Functionalism is the general point of view in psychology with which Angell's name is most closely linked. Many psychologists abroad had refused to follow Wundt's lead on theoretical problems where it was held that the purpose of psychology was an analysis of immediate experience into its elements and attributes, with a later synthesis of the elements into complex processes. James was an outstanding opponent of such a view in this country. When E. B. Titchener accepted the Cornell post in 1892, coming from England and from Wundt's laboratory in Leipzig, the Wundtian systematic point of view was transplanted to America, to be supported by a series of textbooks and articles from Titchener's pen as well as by extensive experimental research from his laboratory, but never to be wholly naturalized in this country. The most trenchant criticisms of this structuralism came from the Chicago group.

American functionalism, or better biological functionalism, opposed the view that the primary purpose of psychology is the analysis of immediate experience into its elements and their attributes by the method of introspection. From the functional point of view, psychology uses both introspective and objective methods in the study, primarily, of consciousness viewed as a psychophysiological process having adaptive value in the adjustment of the organism to its environment. There was room in such a system for all of the verifiable findings of the Wundtian-Titchenerian structuralism, but there was also room for all of the other non-introspective results to be obtained on adaptive behavior by means of mental tests, physiological studies, research on animal behavior, and objective methods in general. The Darwinian influence on such a point of view is obvious and is testified to in one of Angell's papers (1909). If consciousness is one aspect of a psychophysiological whole, it must as a biological process have had an origin in man or in the animals below him and, since it has survived, it must have a useful function in the adaptive life of the organism. In brief, Angell's position was as follows: Consciousness appears (and appeared phylogenetically) when reflexes, instincts, and habits fail to solve the problem which confronts the organism. Consciousness aids in the solution of the problem and then, no problem existing longer at that point, passes on to other points of conflict in the organism's behavior. Were consciousness not in general a problem solver it would have no adaptive value and hence would not have survived as a function of the organism. Not only consciousness in general but consciousness in its various forms has an adaptive function. Thus one should be able to discover the adaptive values of sensation, emotion, memory, and thought. Such a point of view, whether theoretically sound or not, would (and did) encourage an extremely wide variety of experimental studies. In general the theory implies the intervention of consciousness as a causal agency in the stream of natural events and postulates a lapsed intelligence theory of instincts, i.e., that instinctive behavior was originally conscious behavior which through repetition became "unconscious" as habits are alleged to become when they turn into automatic acts. Angell's textbook (1904) gave the first comprehensive application of this functionalistic point of view to psychology.

The origin of Angell's views on functionalism lies first, in James' psychology, and second, in the papers on emotion (1894), the reflex arc (1896), and effort (1897) written by John Dewey. Angell's first experimental work (1896) on the role of attention in determining reaction times involved a functional rather than a structural approach to the problem. As he wrote in explanation later (1898): "Given a situation where a sensation involves a small group of coordinations habitual in type and the movement itself necessitates another such group, the function of attention will be found at that point where the various coordinations comprised in the total sensation-and-movement act are least perfect, least thoroughly habitual." [7]

In a personal letter to the present writer dated April 22, 1925, Angell wrote as follows concerning functionalism: "It was not until I went to Chicago as Assistant Professor under Dewey in 1894—and indeed not for several years after that—that I myself began to use in any effective way the conception that consciousness arises in moments of conflict. My further impression is that, in my own article, written conjointly with A. W. Moore, on reaction time, and in my treatment of the relation of instincts to consciousness [in the 1904 textbook], I gave a rather more definite orientation of the idea you are dealing with as a part of a general system of psychology than any one had previously attempted to do. I had been much influenced by James' conception of habit, and it seemed to me, as you well know from my writing and teaching, that consciousness appeared chronologically in the life of the individual between the activities which were purely instinctive and those which had become purely habitual. This conception of the genetic trinity, i.e., instinct, conscious reaction, habit, I do not now recall getting directly from Dewey in that form, although I dare say I did. I should have to look up the papers to be sure about it; but I certainly got the essential conception of consciousness as connected with conditions of tension in adjustment directly from Dewey. I do not recall ever to have heard him bring that theory into connection with the 'lapsed intelligence' theory of instinct, although the logical nexus is obvious enough. I have never, since my original contact with the idea and my efforts to give it a thorough-going formulation as part of a system of psychology, encountered anything which added materially to my own view. The thing which has always astonished me is that the idea has made no greater headway and has not appealed more vividly to the systematizers in psychology. I still think it is a sound and fruitful idea and, so far as I know, one which is essentially true."

Again in a letter dated March 7, 1934, Angell wrote as follows in acknowledging the receipt of a reprint: "I am naturally much interested in the general issue, for the 'lapsed consciousness doctrine' played a very large part in my own thinking and, while I am now quite out of the field of active participation in such issues, the general conception seems to me extremely persuasive. The particular negative considerations which are referred to in your paper do not seem to me altogether convincing as bases for a general challenge to the lapsed consciousness theory in its broader applications."

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[7] Habit and attention. Psychol. Rev., 1898, 5, 180.

Writing in 1907, Angell had said: "The functional psychologist then in his modern attire is interested not alone in the operations of mental process considered merely of and by and for itself, but also and more vigorously in mental activity as a part of a larger stream of biological forces which are daily and hourly at work before our eyes and which are constitutive of the most important and absorbing part of our world. . . . This is the point of view which instantly brings the psychologist cheek by jowl with the general biologist."[8] He then proceeded to indicate the value of such a psychological viewpoint for the analysis of behavior disorders and for the adequate comprehension of such philosophical problems as the rightness and wrongness of behavior (ethics) or the trueness and falseness of judgments (logic). As early as 1903, Angell was writing that truth and falsehood are simply impressive names for successful and unsuccessful operations of adaptation, a view closely related to that of the instrumental logic being developed by Dewey and to the pragmatism of James. And in the same article he was stressing the dependence of social psychology and scientific ethics upon the concept of adaptation which underlay the functional point of view in psychology. Certainly history has borne out Angell's prediction that a structural psychology could not cope with the growing and expanding problems of the science.

There is an element of irony in the fact that Angell's very emphasis upon the importance of biological adaptation and consequently upon studies in animal behavior should have given rise to, or at least to have been followed by, a point of view in psychology to which he was violently opposed, behaviorism. Although John B. Watson left Angell's department at Chicago in 1908 and did not publish explicitly on behaviorism until 1913, the point of view grew out of the work on animal behavior which Watson and others were doing at Chicago as early as 1903. Behaviorism sought to write a psychology without including consciousness, denying in fact that consciousness could be something for scientific study. This was not merely another objective psychology which left part of the science to a subjective branch. Rather it was contended that an adequate account could be given of all phases of human behavior without making use of the concept of consciousness. This was a far cry from functionalism where consciousness as an instrument of biological adjustment was the central theme. Angell's only extensive writing on behaviorism appeared in 1913 in an article entitled *Behavior as a Category of Psychology*. At that time his attitude was in general friendly, since he had always encouraged objective experimental work irrespective of the introspective method or of the bearing of the work upon problems of consciousness, but he counselled strongly against omitting consciousness altogether from the science. "We must be cautious therefore that in seeking for bettered means of knowing human nature in its entirety we do not in effect commit the crowning absurdity of seeming to deny any practical significance to that which is its chief distinction—the presence of something corresponding to the term mind—the one thing of which the fool may be as sure as the wise man. We may agree then that in theory all and in practice much of our mental life might be stated in terms of objective behavior. To do this would involve trespassing rather freely on the preserves of biology, physiology, and neurology on the one side and upon those of the social sciences on the other. But such trespass is perfectly legitimate provided the trespasser is willing to face the chance that he may find himself annexed, appropriated, and in general swallowed up by the owner of the territory which he invades. . . . At this point too we come upon one of those fundamental lines of cleavage in human interests which cannot be justified, but which nevertheless determine conduct and career. The person to whom mental process as mental process is the only fascinating and ultimately worthy subject of study is not likely to rest content with any such program as that depicted. . . . To such a one any abandonment of introspection must seem a pitiful and mean desertion of the real object of worth. Whether this view permanently prevails or becomes an esoteric scientific cult, it is a safe prediction that we shall always have it with us."[9]

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[8] The province of functional psychology. Psychol. Rev., 1907, 14, 70-71.

It is too much, perhaps, to expect that Angell, long out of direct contact with psychology, would have changed his views in later years. It is no surprise then that in 1936, after over twenty years of behavioristic work in psychology, he wrote as follows: "Exclusive methods, like Watsonian behaviorism, simply beg the question and tacitly assume data which, without essentially introspective processes, performed by their predecessors, if not by the proponents themselves, would be paralyzed and wholly sterile. I may inject in passing that, despite much which seems to me rather ridiculous in its naiveté, I value highly the contribution behaviorism has made both to methodological procedure and to factual knowledge of both human and animal life."[10]

Among other of Angell's contributions to psychology, attention might be called to his trenchant and illuminating criticism of the doctrine of imageless thought which was presented as a lecture at Columbia[11] as well as to his thoughtful weighing of the evidence for and against the James-Lange theory of emotion.[12] In this latter article, after reviewing the evidence, Angell wrote: "James himself, could he but participate in this discussion, would, I am sure, be immensely more interested to discover and define the real facts than to justify any mere theory of his own. And I think he would perhaps urge that, after all controverted points were left aside, the main issues for which he would wish to contend are (1) the instinctive basis of emotional reactions, and (2) the invariable repercussion upon the cortex of these reflex effects in the muscles, glands, and viscera. Phrase your doctrine so that these two great groups of facts are recognized and properly evaluated, and you may call your theory Jamesian or not as you please. You will at least have accepted what lies at the root of James's theory." (p. 261)

Angell's *Chapters from Modern Psychology* (1912) is based on a series of lectures to a general audience at Union College given with the purpose of acquainting such groups with the broad scope and general principles of psychology. The volume was widely used in college courses, and it was the justification to the present writer for the inclusion in his *General Psychology* (1919) of separate chapters on the fields of psychology. The current broadening of the scope of general psychology textbooks which began in 1919 and which still continues may thus be said to have had its original impetus primarily from Angell.

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[9] Behavior as a category of psychology. Psychol. Rev., 1913, 20, 268-269.

[10] Autobiog., 26-27.

[11] Imageless thought: Psychol. Rev., 1911, 18, 295-323.

[12] A reconsideration of James' theory of emotion in the light of recent criticisms. Psychol. Rev., 1916, 23, 251-262.

Angell served as President of Yale from 1921 until his retirement in 1937. During this period his wife died (1931) and he married Katharine Cramer Woodman (1932). After retirement he became educational counselor to the National Broadcasting Company. To this were added duties as trustee of the American Museum of Natural History, curator of Stephens College, director of the Museum of Science and Industry and director of the Hall of Fame. When death came to him, he had completed a great career widely acclaimed by his contemporaries. He had been the recipient of honorary degrees from Berlin, Brown, California, Chicago, Cincinnati, Columbia, Dartmouth, Halle, Harvard, McGill, Michigan, Middlebury, New York, Pennsylvania, Pennsylvania Military College, Rensselaer, Rutgers, Wabash, Wesleyan, Williams, and Yale. He had been decorated Chevalier and Officer of the Legion of Honor, Grand Officer of the Order of the Crown of Italy, Chinese Blue Grand Cordon Order of the Jade, and he had received the gold medal of the National Institute of Social Science. Angell was honored by election to the National Academy of Sciences (1920), the American Philosophical Society (1924), and the American Academy of Arts and Sciences (1932). He served on the Council of the American Psychological Association from 1903 to 1906, and was President of the Association in 1906. From 1912 to 1922 (two years after going to Yale) he served with great wisdom and distinction as the Editor of the *Psychological Monographs.*

KEY TO ABBREVIATIONS USED IN BIBLIOGRAPHY

Amer. J. Sociol. = American Journal of Sociology
Amer. Med. Assoc. = American Medical Association
Amherst Grad. Quart. = Amherst Graduate Quarterly
Educ. Rev. = Educational Review
J. Person. Res. = Journal of Personnel Research
J. Phil. Psychol. = Journal of Philosophy, Psychology, and Scientific Methods.
Phil. Rev. = Philosophical Review
Psychol. Bull. = Psychological Bulletin
Psychol. Monog. = Psychological Monographs
Psychol. Rev. = Psychological Review.
Rev. de mét. et de mor. = Revue de métaphysique et de morale
Scient. Mo. = Scientific Monthly
Soc. Forces = Social Forces
Univ. Chicago Decenn. Publ. = University of Chicago Decennial Publications
Yale Alum. Wkly. = Yale Alumni Weekly

PARTIAL LIST OF PUBLICATIONS BY JAMES ROWLAND ANGELL

1896

(With A. W. Moore) Reaction time: a study in attention and habit. Psychol. Rev., 3, 245-258.

(With S. F. McLennan) The organic effects of agreeable and disagreeable stimuli. Psychol. Rev., 3, 371-378.

1897

Thought and imagery. Phil. Rev., 6, 646-651.

1898

Habit and attention. Psychol. Rev., 5, 179-183.

(With J. N. Spray and E. W. Mahood) An investigation of certain factors affecting the relations of dermal and optical space. Psychol. Rev., 5, 579-594.

1899

(With H. B. Thompson) The relations between certain organic processes and consciousness. Psychol. Rev., 6, 32-69.

1901

(With W. Fite) The monaural localization of sound. Psychol. Rev., 8, 225-246.

(With W. Fite) Further observations on the monaural localization of sound. Psychol. Rev., 8, 449-458.

(With W. Fite) New apparatus. Psychol. Rev., 8, 459-467.

1903

The relations of structural and functional psychology. Phil. Rev., 12, 243-271.

The relation of structural and functional psychology to philosophy. Univ. Chicago Decenn. Publ., 3, p. 21.

A preliminary study of the significance of partial tones in the localization of sound. Psychol. Rev., 10, 1-14.

1904

Psychology: an introductory study of the structure and functions of human consciousness. New York: Holt. P. 402.

1905

Psychology at the St. Louis Congress. J. Phil. Psychol., 2, 533-546.

1906

In the realm of the subconscious. Dial, 41, 106-109.

Recent discussion of feeling. J. Phil. Psychol., 3, 169-174.

1907

The province of functional psychology. Psychol. Rev., 14, 61-91.

1908

The new psychology building at the University of Chicago. Psychol. Bull., 5, 375-376.

The doctrine of formal discipline in the light of the principles of general psychology. Educ. Rev., 36, 1-14.

1909

The ethics of animal experimentation. Chicago: Amer. Med. Assoc., p. 8

The influence of Darwin on psychology. Psychol. Rev., 16, 152-169.

1910

Laboratory courses and equipment in psychology for colleges and universities. Psychol. Monog., 12, 72-79.

Methods for the determination of mental imagery. Psychol. Monog., 13, 61-107.

1911

Williams James. Psychol. Rev., 18, 78-82.

Imageless thought. Psychol. Rev., 18, 295-323.

1912

Chapters from Modern Psychology. New York: Longmans, Green. P. 308.

1913

Behavior as a category of psychology. Psychol. Rev., 20, 255-270.

Professor Watson and the image. J. Phil. Psychol., 10, 609.

1916

A reconsideration of James' theory of emotion in the light of recent criticisms. Psychol. Rev., 23, 251-262.

1918

An introduction to psychology. New York: Holt. P. 281.

1920

The organization of research. Scient. Mo., 11, 26-42.

1922

Reasons and plans for research relating to industrial personnel. J. Person. Res., 1, 1-6.

Psychology in the United States. Rev. de mét. et de mor., No. 4, 381-392.

The evolution of intelligence. Ch. IV in the Evolution of Man. New Haven: Yale Univ. Press. Pp. 103-125.

1929

Modern movements in psychology during the last two decades. Amherst Grad. Quart., 18, 73-86.

Yale's Institute of Human Relations. Yale Alum. Wkly. P. 14.

1931

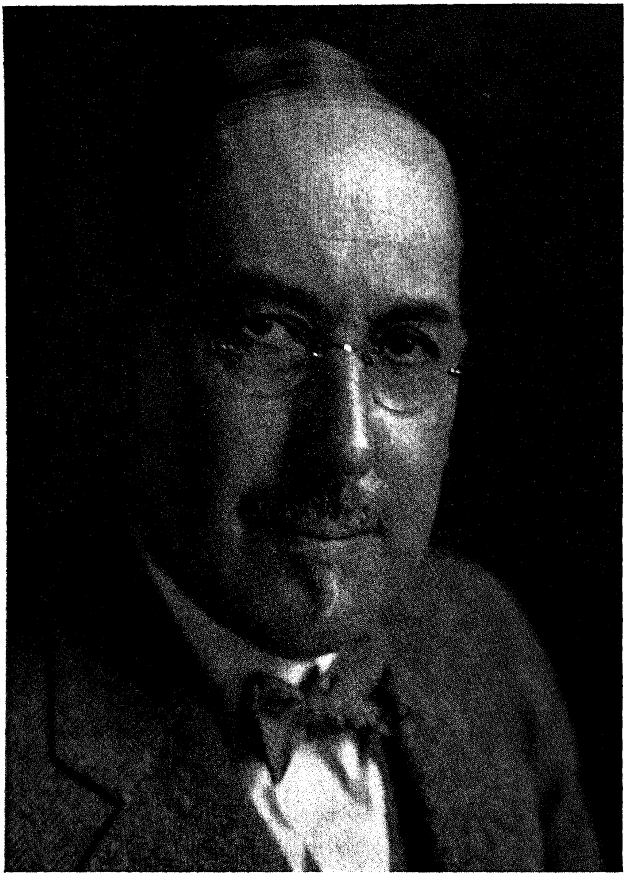
A proposed research technique. Soc. Forces, 10, 204-208.

1936

James Rowland Angell: Autobiography. Ch. I in History of Psychology in Autobiography. Worcester, Mass.: Clark Univ. Press. Pp. 1-38.

1941

Radio and national morale. Amer. J. Sociol., 47, 352-359.



John C. Merriam

JOHN CAMPBELL MERRIAM[1]

1869–1945

BY CHESTER STOCK

The subject of this memoir was born in Hopkinton, Iowa, on October 20, 1869, and died in Oakland, California, on October 30, 1945.

The parents of John C. Merriam were Charles Edward Merriam and Margaret Campbell Kirkwood. He was one of three children. His mother, from whom he received his lasting interest in natural history, was born in Pennsylvania but was brought up in Scotland. His forebears on his father's side were early settlers in America, who in the 50's moved from Massachusetts to Iowa. Charles, his father, entered the Union army before he was sixteen and fought for his country for four years, except for 9 months that he was forced to spend as a prisoner of war in Libbey Prison. In the aftermath of the Civil War, with all of its demoralization, emerged this young man of humble beginnings and high ideals, to become a leader in church and civic affairs, and a trustee of the community college.

This was the environment in which John Campbell Merriam spent his early life. As a boy he came under the influence of Hugh McBride, a botanist and teacher in the local college, for a time President of the University of Iowa. His botanical interests were stimulated by this contact, as were likewise his studies in geological subjects by an acquaintance with Professor Samuel Calvin.

After taking the degree of Bachelor of Science at Lenox College, Iowa, at the age of 16, John C. Merriam with his family moved to Berkeley, California, and it was there that most of his later life was spent. He attended the University of California to study geology under Joseph Le Conte and botany under E. L. Greene, and served as an assistant in mineralogy. As was customary in those days, Merriam went to Europe for advanced study, receiving his doctorate at the University of Munich under Karl von Zittel. His dissertation "Ueber die Pythonomorphen der Kansas-Kreide" proved to be a very fortunate choice, for it gave Merriam opportunity to acquaint himself with the structural characters of living and fossil reptiles—information on which he was to draw in his later studies of Mesozoic marine reptiles of western North America.

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[1] Several biographical accounts of the life of Dr. John Campbell Merriam have already appeared:

Stock, C. (1938) John Campbell Merriam as scientist and philosopher, in Cooperation in Research. Carnegie Inst. Wash. Publ. no. 501, pp. 765-778.

Chaney, R. W. (1945) John Campbell Merriam (1869-1945). Amer. Phil. Soc. Yearbook, pp. 381-387.

Stock, C. (1947) Memorial to John Campbell Merriam. Geol. Soc. Amer. Proc. Vol. for 1946, pp. 183-198.

Although his doctorate was in vertebrate paleontology, Merriam had acquired a very broad training in the geological sciences. On his return to America in 1894 and to an appointment as instructor at the University of California, he was for some years occupied with both the invertebrate and vertebrate branches of paleontology. Between 1896 and 1899 he published papers describing Tertiary molluscan faunas from Vancouver Island and discussing the geologic relations of the Martinez group of California. His papers on the Tertiary echinoids of California remain perhaps his most significant contribution to invertebrate paleontology, for they laid the foundation on which important phylogenetic and stratigraphic studies were based by later investigators. Merriam was among the first to appreciate the significance of evolutionary changes in Tertiary echinoids, and especially the utilization of these organisms as horizon markers of value in an age determination and correlation of deposits in which they are found.

In the course of these studies Merriam was frequently called upon to make identifications of invertebrate fossils collected in Tertiary deposits exposed in the vicinity of San Francisco Bay. He actively cooperated with Andrew C. Lawson in the study of the fossiliferous formations of the Concord quadrangle and in the unraveling of the geological history of that area. His first description of a fossil mammal from the California Tertiary was a result of this geological study. Prior to this description he had already noted in print the occurrence of ichthyosaur remains in northern California, brought to his attention by James Perrin Smith. This resulted six years later in the publication of several reports of his investigations, and culminated in his memoir on the Triassic Ichthyosauria which appeared in 1908. Later, he came to recognize a new order of marine reptiles, namely the Thalattosauria, known for the first time from the Triassic of California.

Vertebrate paleontology continued to claim his major interest, and there followed published accounts by him and by his students of saurian investigations, cave explorations in California, and the geology of the John Day Basin, Oregon. Although these projects had been touched upon by earlier workers—Cope's description, for example, of specimens of the Pleistocene short-faced bear from a limestone cave in Shasta County, Leidy's brief notes on ichthyosaur remains from Nevada, and the work of Cope, Marsh, Wortman, and Scott on the John Day region and its faunas during the period from the sixties to the eighties—Merriam greatly expanded the studies. The projects became with him major explorations, fruitful not only paleontologically, but also geologically and anthropologically. Thus, although much basic paleontological research had been done in the John Day Basin, particularly by eastern workers, it was Merriam who first clearly determined, as a result of his field work, the important sequential stratigraphical events of the region, later published in his classic paper of 1901. Again, the extended studies on the limestone caves of Shasta County and of their Pleistocene fossils, conducted for the most part by his students, but fostered by his interest, led to stimulation of anthropological research at the University of California.

During this period the University was still in its early growth, and departmental budgets for research were small. The struggling paleontologist fortunately made at that time the acquaintance of Miss Annie M. Alexander and enlisted her aid in his research. The generous response of this fine and steadfast patroness of paleontology and zoology, who not only gave so liberally of her possessions but also of her effort and time as field collector, was an important factor in bringing success to Merriam in the principal direction of his interest.

Even before completion of the work on fossil reptiles, his attention turned more strongly toward the study of fossil mammals, western Tertiary mammalian faunas, and early human history. There followed many papers which relate to these fossil assemblages, correlation studies, and to the deposits and faunas of Rancho La Brea. They were published for the most part during the greatest productive period of his research career at the University from 1900 to 1919 and may be regarded as his most significant contributions to paleontology and historical geology. As his extra-paleontological interests gradually enlarged he found less opportunity to engage in actual field studies in geology and paleontology. Thus, where previously he had pursued such investigations as the fossil saurian occurrences in California and Nevada, the geology of the John Day Basin, and the geology and paleontology of the Virgin Valley and Thousand Creek areas of Nevada, later field work was largely accomplished by his graduate students and assistants. These were the years when he exercised his greatest influence on students, and many men receiving instruction from him were subsequently to find responsible posts in science and industry.

Because of previous training and breadth of view, he clearly saw in the conduct of his correlation studies the need of information furnished by stratigraphy, invertebrate paleontology, the various divisions of vertebrate paleontology, and by paleobotany. As a result, when opportunity presented itself, he did not hesitate to enlist the services of others in the development of new or latent fields of research. The wisdom of this has been demonstrated by the marked contributions of Ralph W. Chaney and his associates in Tertiary paleobotany and of Remington Kellogg in his penetrating research on the fossil marine mammals of western America.

During this time he became increasingly active in the affairs of the University and of the community. He was particularly interested in promoting research and in furthering the publication of original investigations. In 1912 President Benjamin Ide Wheeler appointed him chairman of a newly formed Department of Paleontology. At the time of World War I he saw the urgency of a national defense program. He became chairman of the Research Committee, California State Council of Defense, which office he held from 1917 to 1920. In 1919 he was chairman of the National Rêsearch Council. Later, in 1920, he became dean of the faculties at the University.

Although considered a candidate for the presidency of the University of California during the period which followed the retirement of Doctor Wheeler, Merriam accepted the presidency of the Carnegie Institution of Washington (the third president in the history of that Institution). It was his belief that, rather than continue his career as paleontologist, he should serve science broadly and more effectively by becoming head of a great research foundation.

During the next eighteen years he was occupied with the innumerable tasks which face an executive of a large organization. This period of service is perhaps most noteworthy because of a certain centralization of the activities of the Carnegie Institution of Washington. Shortly after his appointment to the presidency, he proposed a plan for the establishment of fellowships in the Institution. This type of appointment, however, was not energetically pursued in subsequent years. Rather, an enlargement continued in the group of research associates who were affiliated with other institutions of learning. He gave stimulus to publication of scientific results and to a dissemination of knowledge gained by eminent scholars of the Institution's staff and associates through popular articles, lectures, conferences and demonstrations. He became more and more impressed with the need for cooperation among men of science in the solution of many of their problems. This may be exemplified by his establishment of a committee in 1925 for the study of the surface features of the moon. The committee, under the able chairmanship of Dr. Fred. E. Wright, sought to examine the problem from all feasible points of view, and according to Merriam, "illustrates in an extremely interesting way the possibilities of study by groups of investigators approaching a problem from different positions, and with quite different objectives." The committee included in its membership not only the astronomer, but also the volcanologist, the physiographer, the geologist, the physicist, and the mathematician, and represented the cooperation of many institutions.

Merriam was responsible for the establishment of a program of research in regional seismology on the Pacific Coast under the auspices of the Institution and administered by an Advisory Committee of which Dr. Arthur L. Day was chairman. Out of this program grew the development of the Seismological Laboratory on a cooperative plan of the Institution, the California Institute of Technology, and others. He was also much interested in the program of archeological research in southern Mexico and Guatemala, and on occasion found time to visit the localities where the fascinating records of early civilizations in the New World were being uncovered. Later, these investigations in human history included studies of early man in America and in Asia. It was natural that paleontology and paleobotany received added support during his period of incumbency as President of the Carnegie Institution. Thus it was possible for Chaney to widely extend his studies of recent and fossil plants not only over the North American continent, but also in Asia and South America, and for Stock and his associates to explore extensively the later Cenozoic formations and faunas of western North America.

However, by no means were all of Merriam's activities confined to the Carnegie Institution of Washington. Doctor Merriam served for a time as a Regent of the Smithsonian Institution. He fostered the unique educational features of some of the national parks. He was President of the Executive Committee of the Pan-American Institute of Geography and History from 1935 to 1938. As pointed out by Dr. Chaney:

"Perhaps the most timely activity of this most productive life was his founding of the Save-the-Redwoods League, with Henry Fairfield Osborn and Madison Grant in 1917. Not a single coast redwood along the highway was then publicly owned, and the finest forests were being cut for lumber. During the nearly thirty years ensuing more than 45,000 acres of redwood forest have been set aside as State parks, at a cost of $7,500,000. For thirty miles along the Redwood Highway these trees rise to stimulate the imagination of the visitor who sees in Sequoias the oldest living things, who comes to recognize in them a kind of beauty associated only with antiquity. Bull Creek Flat, a thousand-acre forest of giant redwoods maintained in its natural state, represents the high achievement of a man who, as President of the League for nearly a quarter of a century, guided this major project of conservation. . . ."

These were the years when Merriam brought to publication most of the articles and essays of a more general and philosophical nature. His interest in the human values derived from education and research led to the publication of his book, *The Living Past*. On his retirement in 1938, the Carnegie Institution reprinted all his papers and addresses and published likewise an appreciation volume entitled: *Cooperation in Research by Staff Members and Research Associates.*

Throughout his later busy yet contemplative years Doctor Merriam was an ardent student of poetry, finding communion and kinship of thought with his favored English poets—Shelley, Wordsworth, Tennyson, and Keats—as well as with such American poets as William Cullen Bryant and Alfred Noyes. He drew frequently from their works in his discussions, conversation, and writings. After his retirement he published a series of articles of general scope and philosophical import in his second book called: *The Garment of God.* He continued to concern himself with the national parks of the West and with the State parks of Oregon. Largely through his activity, the group known as the John Day Associates was established with the purpose of conserving the famous fossil beds of the John Day Basin, and of developing public interest in the geological story so clearly told by the rocks and fossils of the region.

Doctor Merriam's eminence in science was recognized and acknowledged in several ways. Honorary degrees were awarded him by many universities. In addition to fellowship in The Geological Society of America (he held the presidency in 1919), he was a member of the Society of Vertebrate Paleontology, President of the Paleontological Society in 1910, President of the American Society of Naturalists in 1936. He was a member of the National Academy of Sciences and likewise a councilor and vice-president, a member of the American Philosophical Society, the American Academy of Arts and Sciences, the

Academia Nacional de Ciencias Antonio Alzate de Mexico, and Sociedad de Geografia e Historia de Guatemala. A gold medal was awarded him by the American Institute, New York.

In the span of his life Doctor Merriam became engrossed with many problems, and it is safe to say that in the solution of some of these, perhaps not all, he found some of his happiest moments. Beginning with a central interest in geological science, he became in the course of time an educator, conservationist, administrator, and philosopher. He will be known to future geologists particularly for his careful, painstaking researches in stratigraphical geology and vertebrate paleontology. It was Merriam who first developed the latter subject in the western half of North America from its pioneering stage to an established discipline.

The last years of his life were spent for the most part on the Pacific coast. He continued to serve on the Advisory Committee of the California Institute of Technology and occupied offices in its Division of the Geological Sciences.

Not a robust person, but rather one of medium stature and slender build, Merriam presented the demeanor of the professional man. At the height of his administrative powers he found relaxation in summer visits to the field camps of his paleontological associates. During the early years of his career at the University, his favorite sports were shooting ducks in the tule lands of the San Francisco Bay region and fishing for trout in the streams of northern California. He was by nature not genial, but rather grave and distant; his conversation was usually in a serious vein. As a lecturer in the classroom Merriam became a polished speaker, capable of holding and enthralling the audience with his subject matter. These qualities were likewise evident in his public addresses.

Ada Gertrude Little, whom he married in 1896, was his devoted wife for more than twoscore years and gave him care, comfort, and stimulus, asking only the joy of accomplishment with him. He never quite found solace in his own activities after her death. They are survived by three sons, a forestry engineer now with the U. S. Park Service as a regional director, a geologist, and an economist. Surviving Doctor Merriam likewise are a sister, Susan Merriam Gearhart, and a brother, Charles Edward Merriam, Professor emeritus of political science at the University of Chicago, and at one time a mayorality candidate of the city of Chicago.

Doctor John Campbell Merriam left the impress of his thoughts and deeds on students and men and women in many walks of life. By them he will be long remembered.

KEY TO ABBREVIATIONS USED IN BIBLIOGRAPHY

Amer. Anthrop. = American Anthropologist
Amer. Civic Ann. = American Civic Annual
Amer. Found. Mental Hygiene = American Foundation for Mental Hygiene
Amer. Journ. Sci. = American Journal of Science
Amer. Mag. Art = American Magazine of Art
Amer. Phil. Soc. Trans., n.s. = American Philosophical Society, Transactions, new series
Ann. Conv. Middle States Assn. Coll. & Secondary Schools = Annual Convention Middle States Association of Colleges and Secondary Schools.
Assn. Amer. Univ. Proc. = Association of American Universities, Proceedings.
Buffalo Soc. Nat. Hist. = Buffalo Society of Natural History
Calif. Acad. Sci. Mem. = California Academy of Sciences, Memoirs
Calif. Acad. Sci. Proc. = California Academy of Sciences, Proceedings
Carn. Inst. Wash. N. S. Bull. = Carnegie Institution of Washington, News Service Bulletin
Carn. Inst. Wash. Publ. = Carnegie Institution of Washington, Publication
Commonwealth Club Calif. Trans. = Commonwealth Club of California Transactions
Educ. Rec. (Wash.) = Educational Record (Washington)
Elect. Eng. (N.Y.) = Electrical Engineering (New York)
Geol. Soc. Amer. Bull. = Geological Society of America, Bulletin
Geol. Surv. Fla. Rpt. = Geological Survey of Florida, Report
Geo. Wash. Univ. Bull. = George Washington University Bulletin
Harper's Mo. Mag. = Harper's Monthly Magazine
Inaug. Bull. Univ. Ariz. = Inaugural Bulletin, University of Arizona
Inter. Geol. Cong. = International Geologic Congress
Journ. Adult Educ. = Journal of Adult Education
Journ. Geol. = Journal of Geology
L. A. Daily Journ. = Los Angeles Daily Journal
Nat. Acad. Sci. Proc. = National Academy of Sciences, Proceedings
Nat. Conf. Outdoor Rec. = National Conference on Outdoor Recreation
Nat. Hist. Bull. = Natural History Bulletin
Nat. Parks Bull. = National Parks Bulletin
Nat. Res. Prod. Dept. = Natural Resources Production Department
Pan-Amer. Geol. = Pan-American Geologist
Pan-Amer. Inst. Geol. & Hist. Proc. = Pan-American Institute of Geology and History Proceedings
Pop. Sci. Mo. = Popular Science Monthly
Rice Inst. Pamph. = Rice Institute Pamphlet

Sci. Assn. Univ. Calif., Proc. = Science Association of University of California, Proceedings
Sci. N. L. = Science News Letter
Sci., n.s. = Science, new series
Sci. Amer. = Scientific American
Sci. Mo. = Scientific Monthly
So. Calif. Acad. Sci. Bull. = Southern California Academy of Science, Bulletin
Sunset Mag. = Sunset Magazine
Univ. Calif. Publ., Bull. Dept. Geol. = University of California Publications, Bulletin, Department of Geology
Univ. Calif. Mag. = University of California Magazine
Univ. Calif. Mem. = University of California Memoirs
Univ. Va. Alumni Bull. = University of Virginia Alumni Bulletin
U. S. Geol. Surv. = United States Geological Survey

BIBLIOGRAPHY

1891

Thoughts for Arbor Day. Lenox Nutshell (Hopkinton, Iowa), vol. 5, no. 11, pp. 123-125.

1894

Ueber die Pythonomorphen der Kansas-Kreide. Palaeontographica, vol. 41, pp. 1-39.

1895

On some reptilian remains from the Triassic of northern California. Amer. Journ. Sci., ser. 3, vol. 50, no. 295, pp. 55-57.

1896

Sigmogomphius Le Contei: a new castoroid rodent from the Pliocene near Berkeley, California. Univ. Calif. Publ.; Bull. Dept. Geol., vol. 1, no. 13, pp. 363-370

Note on two Tertiary faunas from the rocks of the southern coast of Vancouver Island. Univ. Calif. Publ., Bull. Dept. Geol., vol. 2, no. 3, pp. 101-108.

1897

New species of Tertiary Mollusca from Vancouver Island. Nautilus, vol. 11, no. 6, pp. 64-65.

The geologic relations of the Martinez group of California at the typical locality. Jour. Geol., vol. 5, no. 8, pp. 767-775.

1898

The distribution of the Neocene sea-urchins of middle California, and its bearing on the classification of the Neocene formations. Univ. Calif. Publ., Bull. Dept. Geol., vol. 2, no. 4, pp. 109-118.

The fossil human remains of Table Mountain. Lenox Nutshell (Hopkinton, Iowa).

1899

The Tertiary sea-urchins of middle California. Calif. Acad. Sci. Proc., ser. 3, geol., vol. 1, no. 5, pp. 161-174.

The fauna of the Sooke beds of Vancouver Island. Calif. Acad. Sci. Proc., ser. 3, geol., vol. 1, no. 6, pp. 175-180.

Report on the expedition to the John Day fossil beds. Univ. Chronicle, vol. 2, no. 3, pp. 217-224; reprinted in Sci. Assn. Univ. Calif., Proc. General Meetings, vol. 1, no. 1, pp. 3-10.

1900

Ground sloths in the California Quaternary. Geol. Soc. Amer. Bull., vol. 11, pp. 612-614.

1901

The John Day fossil beds. Harper's Mo. Mag., vol. 102, no. 610, pp. 581-590.

A contribution to the geology of the John Day Basin. Univ. Calif. Publ., Bull. Dept. Geol., vol. 2, no. 9, pp. 269-314.

Some observations on cloud-bursts. Univ. Calif. Mag., vol. 7, no. 3, pp. 113-116.

Geology in California. Univ. Calif. Mag., vol. 7, p. 192.

The geological work of Professor Joseph Le Conte. Univ. Calif. Mag., vol. 7, p. 214.

1902

Triassic Ichthyopterygia from California and Nevada. Univ. Calif. Publ., Bull. Dept. Geol., vol. 3, no. 4, pp. 63-108.

1903

New Ichthyosauria from the upper Triassic of California. Univ. Calif. Publ., Bull. Dept. Geol., vol. 3, no. 12, pp. 249-263.

Recent literature on Triassic Ichthyosauria. Sci., n.s., vol. 18, no. 453, pp. 311-312.

The Pliocene and Quaternary Canidae of the Great Valley of California. Univ. Calif. Publ., Bull. Dept. Geol., vol. 3, no. 14, pp. 277-290.

1904

A note on the fauna of the lower Miocene in California. Univ. Calif. Publ., Bull. Dept. Geol., vol. 3, no. 16, pp. 377-381.

A new marine reptile from the Triassic of California. Univ. Calif. Publ., Bull. Dept. Geol., vol. 3, no. 21, pp. 419-421.

1905

The types of limb-structure in the Triassic Ichthyosauria. Amer. Journ. Sci., ser. 4, vol. 19, pp. 23-30.

A primitive ichthyosaurian limb from the middle Triassic of Nevada. Univ. Calif. Publ., Bull. Dept. Geol., vol. 4, no. 2, pp. 33-38.

The Thalattosauria: a group of marine reptiles from the Triassic of California. Calif. Acad. Sci. Mem., vol. 5, no. 1, pp. 1-52.

A new group of marine reptiles from the Triassic of California. Comptes rendus du 6 Congres internationale de Zoologie (Berne, 1904), pp. 247-248.

A new sabre-tooth from California. Univ. Calif. Publ., Bull. Dept. Geol., vol. 4, no. 9, pp. 171-175.

The occurrence of ichthyosaur-like remains in the upper Cretaceous of Wyoming. Sci., n.s., vol. 22, no. 568, pp. 640-641.

1906

Recent cave exploration in California. Amer. Anthrop., ser. 2, vol. 8, no. 2, pp. 221-228; Congres internationale des americanistes, XV session (Quebec, 1906), vol. 2, pp. 139-146.

On the occurrence of *Desmostylus,* Marsh. Sci., n.s., vol. 24, No. 605, pp. 151-152.

Recent discoveries of Quaternary mammals in southern California. Sci., n.s., vol. 24, no. 608, pp. 248-250.

Carnivora from the Tertiary formations of the John Day region. Univ. Calif. Publ., Bull. Dept. Geol., vol. 5, no. 1, pp. 1-64.

Preliminary note on a new marine reptile from the middle Triassic of Nevada. Univ. Calif. Publ., Bull. Dept. Geol., vol. 5, no. 5, pp. 75-79.

1907

The occurrence of middle Tertiary mammal-bearing beds in northwestern Nevada. Sci., n.s., vol. 26, no. 664, pp. 380-382.

(With William J. Sinclair.) Tertiary faunas of the John Day region. Univ. Calif. Publ., Bull. Dept. Geol., vol. 5, no. 11, pp. 171, 205.

1908

Notes on the osteology of the thallattosaurian genus *Nectosaurus.* Univ. Calif. Publ., Bull. Dept. Geol., vol. 5, no. 13, pp. 217-223.

Triassic Ichthyosauria, with special reference to the American forms. Univ. Calif. Mem., vol. 1, no. 1, pp. 1-196.

Death trap of the ages. Sunset Mag., vol. 21, no. 6, pp. 467-475.

1909

The skull and dentition of an extinct cat closely allied to *Felis atrox* Leidy. Univ. Calif. Publ., Bull. Dept. Geol., vol. 5, no. 20, pp. 291-304.

Note on the occurrence of human remains in Californian caves. Sci., n.s., vol. 30, no. 772, pp. 531-532.

The occurrence of strepsicerine antelopes in the Tertiary of northwestern Nevada. Univ. Calif. Publ., Bull. Dept. Geol., vol. 5, no. 22, pp. 319-330.

A death-trap which antedates Adam and Eve: the discovery of a Californian tar-swamp that holds the bones of extinct monsters. Harper's Weekly, vol. 53, pp. 11-12.

1910

The skull and dentition of a primitive ichthyosaurian from the middle Triassic. Univ. Calif. Publ., Bull. Dept. Geol., vol. 5, no. 24, pp. 381-390.

New Mammalia from Rancho La Brea. Univ. Calif. Publ., Bull. Dept. Geol., vol. 5, no. 25, pp. 391-395.

The true story of the *Calaveras* skull. Sunset Mag., vol. 24, pp. 153-158.

Tertiary mammal beds of Virgin Valley and Thousand Creek in northwestern Nevada: Part I, Geologic history. Univ. Calif. Publ., Bull. Dept. Geol., vol. 6, no. 2, pp. 21-53.

Synopsis of lectures in paleontology 1: principles involved in a discussion of the history of life. Univ. Calif. Syllabus ser., no. 20. i plus 32 pp. interleaved. (December 1; reprinted 1913, August 1917; revised August 1919.)

The relation of paleontology to the history of man, with particular reference to the American problem. Pop. Sci. Mo., vol. 77, pp. 597-601.

1911

Note on a gigantic bear from the Pleistocene of Rancho La Brea. Univ. Calif. Publ., Bull. Dept. Geol., vol. 6, no. 6, pp. 163-166.

A collection of mammalian remains from Tertiary beds in the Mohave Desert. Univ. Calif. Publ., Bull. Dept. Geol., vol. 6, no. 7, pp. 167-169.

Tertiary mammal beds of Virgin Valley and Thousand Creek in northwestern Nevada: Part II, Vertebrate faunas. Univ. Calif. Publ., Bull. Dept. Geol., vol. 6, no. 11, pp. 199-304.

Notes on the relationships of the marine saurian fauna described from the Triassic of Spitzbergen by Wiman. Univ. Calif. Publ., Bull. Dept. Geol., vol. 6, no. 13, pp. 317-327.

(With Harold C. Bryant.) Notes on the dentition of *Omphalosaurus*. Univ. Calif. Publ., Bull. Dept. Geol., vol. 6, no. 14, pp. 329-332.

Notes on the genus *Desmostylus* of Marsh. Univ. Calif. Publ., Bull. Dept. Geol., vol. 6, no. 18, pp. 403-412.

The fauna of Rancho La Brea: Part I, Occurrence. Univ. Calif. Mem., vol. 1, no. 2, pp. 197-213.

1912

Marine reptiles: ten years' progress in vertebrate paleontology. Geol. Soc. Amer. Bull., vol. 23, pp. 221-223.

Recent discoveries of Carnivora in the Pleistocene of Rancho La Brea. Univ. Calif. Publ., Bull. Dept. Geol., vol. 7, no. 3, pp. 39-46.

The fauna of Rancho La Brea: Part II, Canidae. Univ. Calif. Mem., vol. 1, no. 2, pp. 215-272.

1913

Tapir remains from late Cenozoic beds of the Pacific Coast region. Univ. Calif. Publ., Bull. Dept. Geol., vol. 7, no. 9, pp. 169-175.

The skull and dentition of a camel from the Pleistocene of Rancho La Brea. Univ. Calif. Publ., Bull. Dept. Geol., vol. 7, no. 14, pp. 305-323.

A peculiar horn or antler from the Mohave Miocene of California. Univ. Calif. Publ., Bull. Dept. Geol., vol. 7, no. 16, pp. 335-339.

Notes on the canid genus *Tephrocyon*. Univ. Calif. Publ., Bull. Dept. Geol., vol. 7, no. 18, pp. 359-372.

Vertebrate fauna of the Orindan and Siestan beds in middle California. Univ. Calif. Publ., Bull. Dept. Geol., vol. 7, no. 19, pp. 373-385.

Preliminary report on the horses of Rancho La Brea. Univ. Calif. Publ., Bull. Dept. Geol., vol. 7, no. 21, pp. 397-418.

New anchitheriine horses from the Tertiary of the Great Basin area. Univ. Calif. Publ., Bull. Dept. Geol., vol. 7, no. 22, pp. 419-434.

New protohippine horses from Tertiary beds on the western border of the Mohave Desert. Univ. Calif. Publ., Bull. Dept. Geol., vol. 7, no. 23, pp. 435-441.

1914

The Brea maid. So. Calif. Acad. Sci. Bull., vol. 13, no. 2, pp. 27-29.

Preliminary report on the discovery of human remains in an asphalt deposit at Rancho La Brea. Sci., n.s., vol. 40, no. 1023, pp. 198-203.

(With Andrew C. Lawson and various students of University of California.) Vertebrate fossils found in region about San Francisco, California. Description of the San Francisco district: Tamalpais, San Francisco, Concord, San Mateo, and Haywards Quadrangles. U. S. Geol. Surv., Geologic atlas of the U. S., Folio no. 193.

Correlation between the Tertiary of the Great Basin and that of the marginal marine province of California. Sci., n.s., vol. 40, no. 1035, pp. 643-645.

The occurrence of Tertiary mammalian remains in northeastern Nevada. Univ. Calif. Publ., Bull. Dept. Geol., vol. 8, no. 12, pp. 275-281.

1915

An occurrence of mammalian remains in a Pleistocene lake deposit at Astor Pass, near Pyramid Lake, Nevada. Univ. Calif. Publ., Bull. Dept. Geol., vol. 8, no. 21, pp. 377-382.

Remains of land mammals from marine Tertiary beds in the Tejon Hills, California. Univ. Calif. Publ., Bull. Dept. Geol., vol. 8, no. 13, pp. 283-288.

Extinct faunas of the Mohave Desert, their significance in a study of the origin and evolution of life in America. Pop. Sci. Mo., vol. 86, no. 3, pp. 245-264.

Asphalt beds of Rancho La Brea. Univ. Calif., Blue and Gold, p. 8.

Significant features in the history of life on the Pacific Coast. Nature and Science on the Pacific Coast, pp. 88-103. Paul Elder & Co., San Francisco.

State agencies of university publication. Assn. Amer. Univ. Proc., 16th Ann. Conf., 1914, pp. 50-59; published also in modified form in School and Society, vol. 1, no. 25, pp. 871-879.

New species of the *Hipparion* group from the Pacific Coast and Great Basin provinces of North America. Univ. Calif. Publ., Bull. Dept. Geol., vol. 9, no. 1, pp. 1-8.

Tertiary vertebrate faunas of the north Coalinga region of California: a contribution to the study of palaeontologic correlation in the Great Basin and Pacific Coast provinces. Amer. Phil. Soc. Trans., n.s., vol. 22, pt. 3, pp. 191-234.

New horses from the Miocene and Pliocene of California. Univ. Calif. Publ., Bull. Dept. Geol., vol. 9, no. 4, pp. 49-58.

1916

Tertiary vertebrate fauna from the Cedar Mountain region of western Nevada. Univ. Calif. Publ., Bull. Dept. Geol., vol. 9, no. 13, pp. 161-198.

Relationship of *Equus* to *Pliohippus* suggested by characters of a new species from the Pliocene of California. Univ. Calif. Publ., Bull. Dept. Geol., vol. 9, no. 18, pp. 525-534.

(With Chester Stock and Clarence L. Moody.) An American Pliocene bear. Univ. Calif. Publ., Bull. Dept. Geol., vol. 10, no. 7, pp. 87-109.

Note on a tooth of *Merychippus* from Florida. Geol. Surv. Fla. Rpt., vol. 8, p. 88.

Mammalian remains from the Chanac formation of the Tejon Hills, California. Univ. Calif. Publ., Bull. Dept. Geol., vol. 10, no. 8, pp. 111-127.

Mammalian remains from a late Tertiary formation at Ironside, Oregon. Univ. Calif. Publ., Bull. Dept. Geol., vol. 10, no. 9, pp. 129-135.

1917

(With John P. Buwalda.) Age of strata referred to the Ellensburg formation in the White Bluffs of the Columbia River. Univ. Calif. Publ., Bull. Dept. Geol., vol. 10, no. 15, pp. 255-266.

Scientific Research. Commonwealth Club Calif. Trans., vol. 12, no. 2, pp. 69-70, 80, 83-84, 90, 96, 104, 107, 111.

Relationships of Pliocene mammalian faunas from the Pacific Coast and Great Basin provinces of North America. Univ. Calif. Publ., Bull. Dept. Geol., vol. 10, no. 22, pp. 421-443.

Applications of science in mobilization. (Remarks on paper by George Ellery Hale.) Commonwealth Club Calif. Trans., vol. 12, no. 9, pp. 399-408.

1918

New mammalia from the Idaho formation. Univ. Calif. Publ., Bull. Dept. Geol., vol. 10, no. 26, pp. 523-530.

Note on the systematic position of the wolves of the *Canis dirus* group. Univ. Calif. Publ., Bull. Dept. Geol., vol. 10, no. 27, pp. 531-533.

New puma-like cat from Rancho La Brea. Univ. Calif. Publ., Bull. Dept. Geol., vol. 10, no. 28, pp. 535-537.

Evidence of mammalian palaeontology relating to the age of Lake Lahontan. Univ. Calif. Publ., Bull. Dept. Geol., vol. 10, no. 25, pp. 517-521.

1919

Tertiary mammalian faunas of the Mohave Desert. Univ. Calif. Publ., Bull. Dept. Geol., vol. 11, no. 5, pp. 437a-437e, 438-585.

The beginnings of human history read from the geological record: the emergence of man. Part one. Sci. Mo., vol. 9, no. 3, pp. 193-209.

War time advances in science. Commonwealth Club Calif. Trans., vol. 14, no. 9, pp. 380-381, 393-394.

The contributions of research. Commonwealth Club Calif. Trans., vol. 14, no. 9, pp. 405-411.

1920

The beginnings of human history read from the geological record: the emergence of man. Part two. Sci. Mo., vol. 10, no. 4, pp. 321-342.

The function of educational institutions in development of research. Univ. Calif. Chronicle, vol. 22, no. 2, pp. 133-142.

The beginnings of human history read from the geological record: the emergence of man. Part three. Sci. Mo., vol. 10, no. 5, pp. 425-437.

Introductory note to "Save the Redwoods," by John Muir. Sierra Club Bull. (San Francisco), vol. 11, no. 1, p. 1.

Address of welcome to the delegates on occasion of the inauguration of David Prescott Barrows, Monday, March 22, 1920. Univ. Calif. Chronicle, vol. 22, no. 3, pp. 288-297.

Earth sciences as the background of history. Geol. Soc. Amer. Bull., vol. 31, pp. 233-246; Sci. Mo., vol. 12, no. 1, pp. 5-17.

Frank Slater Daggett. Sci., n.s., vol. 52, no. 1341, p. 242.

The teaching of historical geology as a factor conditioning research. Geol. Soc. Amer. Bull., vol. 31, pp. 339-349.

The research spirit in everyday life of the average man. Sci., n.s., vol. 52, no. 1351, pp. 473-478.

1921

Origin and history of the bear family in the western hemisphere, with particular reference to the relation of this question to problems of geographical history. Nat. Acad. Sci. Proc., vol. 7, no. 7, pp. 183-185.

An outline of progress in palaeontological research on the Pacific Coast. Univ. Calif. Publ., Bull. Dept. Geol., vol. 12, no. 3, pp. 237-266.

(With Chester Stock.) Occurrence of Pleistocene vertebrates in an asphalt deposit near McKittrick, California. Sci., n.s., vol. 54, no. 1406, pp. 566-567.

Report of the President of the Carnegie Institution of Washington. (1921-1938). Carn. Inst. Wash. Year Book, nos. 20-37.

(And associates.) Continuation of palaeontological researches. (1921-1938). Carn. Inst. Wash. Year Book, nos. 20-37.

(With Chester Stock.) Notes on peccary remains from Rancho La Brea. Univ. Calif. Publ., Bull. Dept. Geol., vol. 13, no. 2, pp. 9-17.

1922

The breadth of an education. Univ. Va. Alumni Bull., ser. 3, vol. 15, no. 3, pp. 268-274.

Common aims of culture and research in the university. Sci., n.s., vol. 56, no. 1445, pp. 263-269.

1924

History and Education. Geo. Wash. Univ. Bull., vol. 23, no. 1, 12 pp.

The National Academy of Sciences. Sci., n.s., vol. 59, no. 1532, pp. 407-408; Nat. Acad. Sci. Ann. Rpt., fiscal year 1923-1924, pp. 46-49.

Recreational, economic, and scientific values of wild life. Nat. Conf. Outdoor Rec., 68th Cong., 1st Sess., Sen. Doc. no. 151, pp. 17-21; Playground (New York), vol. 18, no. 4, pp. 203-204.

Present status of investigations concerning antiquity of man in California. Sci., n.s., vol. 60, no. 1540, pp. 1-2.

Dedication address. (Dedication of the Franklin K. Lane Memorial Redwood Grove, August 24, 1924.) Pp. 3-5.

1925

Recent progress in seismological research. "Earthquake studies." Commonwealth Club. Calif. Trans., vol. 20, no. 6, pp. 208-214.

(With Chester Stock.) Relationships and structure of the short-faced bear, *Arctotherium* from the Pleistocene of California. Carn. Inst. Wash. Publ. 347, paper I, pp. 1-35.

(With Chester Stock.) A llama from the Pleistocene of McKittrick, California. Carn. Inst. Wash. Publ. 347, paper II, pp. 37-42.

(With Chester Stock and C. L. Moody.) The Pliocene Rattlesnake formation and fauna of eastern Oregon, with notes on the geology of the Rattlesnake and Mascall deposits. Carn. Inst. Wash. Publ. 347, paper III, pp. 43-92.

1926

Ancient footprints in the Grand Canyon. Scribner's Mag., vol. 79, no. 1, pp. 77-82; republished with revisions and additions, under the title "Footprints on the path of history," as chapter 6 *in* The Living Past, pp. 95-110. (1930).

Statement of Dr. John C. Merriam on National Arboretum. Hearings before the Comm. on Agri., House of Rep., 69th Cong., 1st Sess., on House Rec. 3890, Jan. 19, 1926, (Ser. E), pp. 16-19.

The responsibility of Federal and State governments for recreation. Nat. Parks Bull. (Wash.), vol. 7, no. 49, pp. 5-8; Nat. Conf. Outdoor Rec., 69th Cong., 1st Sess., Sen. Doc. no. 117, pp. 30-35.

International cooperation in historical research. Pan-Amer. Union Bull., vol. 60, no. 3, pp. 219-222.

Panama and the problem of human migration. Pan-Amer. Union Bull., vol. 60, no. 8, pp. 787-789.

A National Park creed. Nat. Parks Bull. (Wash.), vol. 8, no. 50, p. 3; vol. 9, no. 54, p. 5.

Medicine and the evolution of society. Sci., n.s., vol. 64, no. 1669, pp. 603-609.

1927

The story of a leaf. Scribner's Mag., vol. 81, no. 2, pp. 130-134; republished with slight revisions as chapter 3 *in* The Living Past, pp. 41-54. (1930).

Remarks on the problem of the Smithsonian Institution. Conf. on Future of Smithsonian Inst., Feb. 11, 1927 (Wash.), Proc., pp. 60-65.

Are the days of creation ended? Scribner's Mag., vol. 81, no. 6, pp. 612-618; republished with slight revisions as chapter 7 *in* The Living Past, pp. 113-144. (1930).

Inspiration and education in national parks. Nat. Parks Bull. (Wash.), vol. 9, no. 53, pp. 3-5.

The cave of the magic pool: the meaning of a fragment. Scribner's Mag., vol. 82, no. 3, pp. 264-272; republished with slight revisions, under the title "The meaning of a fragment," as chapter 1 *in* The Living Past, pp. 3-26. (1930).

Our sister societies. Amer. Phil. Soc. Proc., vol. 66, pp. 737-738.

(With Chester Stock.) A hyaenarctid bear from the later Tertiary of the John Day Basin of Oregon. Carn. Inst. Wash. Publ. 346, paper III, pp. 39-44.

1928

What science can do for forestry. Rept. of the Conf. on Commercial Forestry, Nat. Res. Prod. Dept., Chamber of Commerce of U. S., Wash., pp. 167-173.

Charles Doolittle Walcott, Secretary of the Smithsonian Institution 1907-1927. Smithsonian Misc. Coll., vol. 80, no. 12 (Smithsonian Publ. 2964), pp. 5-9.

Doctor Walcott as a paleontologist, and his relations with the Carnegie Institution of Washington. (Address at memorial meeting for Charles Doolittle Walcott, Jan. 24, 1928.)

(With Charles W. Gilmore.) An ichthyosaurian reptile from marine Cretaceous of Oregon. Carn. Inst. Wash. Publ. 393, paper I, pp. 1-4.

Forest windows. Scribner's Mag., vol. 83, no. 6, pp. 733-737; republished with revisions, under the title "A living link in history," as chapter 4 *in* The Living Past, pp. 57-70.

Parks as an opportunity and responsibility of the States. State Recreation (Wash.), vol. 2, no. 4, pp. 10-15.

(With Chester Stock.) A further contribution to the mammalian fauna of the Thousand Creek Pliocene, northwestern Nevada. Carn. Inst. Wash. Publ. 393, paper II, pp. 5-21.

1929

Reports with recommendations from the Committee on Study of Educational Problems in National Parks. (John C. Merriam, chairman, Harold C. Bryant, Hermon C. Bumpus, Vernon Kellogg, and Frank R. Oastler.) Nat. Parks Bull. (Wash.), vol. 9, no. 56, p. 4.

Thomas Chrowder Chamberlin. Dictionary of Amer. Biog., vol. 3, pp. 600-601, New York, Scribner.

The Carnegie Institution of Washington. Reprint from Forschungsinstitute, ihre Geschichte, Organisation und Ziele, 17 pp., edited by Ludolph Brauer, A. Mendelssohn Bartholdy, and Adolf Meyer. Hamburg: Paul Hartung Verlag.

Lessons of the past as guides for the future. Carn. Inst. Wash. News Serv. Bull., ser. no. 38, 1929 ser., no. 7, pp. 41-46.

The twenty-fifth anniversary of initiation of research in the Carnegie Institution of Washington. Sci., n.s., vol. 69, no. 1797, pp. 585-588.

Preservation of the sequoia forests. Amer. Civic Ann., pp. 116-117.

The meaning of the national parks. Amer. Forests and Forest Life (Wash.), vol. 35, no. 8, pp. 471-472, 542; Nat. Parks Bull. (Wash.), vol. 10, no. 57, p. 1.

Natural phenomena as a source of inspiration in education. Educ. Rec. (Wash.), vol. 10, pp. 272-276.

The contribution of science toward the appreciation of nature. Buffalo Soc. Nat. Hist., 1861-1929, 68th Ann. Rpt., July 1, 1928-June 30. 1929, pp. 7-12.

The place of geology among the sciences. Sci., n.s., vol. 70, no. 1821, pp. 491-493.

Reports of John C. Merriam on studies of educational problems in national parks. Individual reports of members of the Committee on Educational Problems in National Parks, Nov. 27, 1929, pp. 17-23, 25-29. Privately printed, Wash.

1930

Institutes for research in the natural sciences. Assn. Amer. Univ. Proc., 31st Ann. Conf., 1929, pp. 55-62.

The Living Past. xi + 144 pp. New York, Scribner.

The practical significance of studies in early human history. Amer. Anthrop., ser. 2, vol. 32, no. 1, pp. 196-198.

The significance of the border area between natural and social sciences. The New Social Science, edited by Leonard D. White, pp. 28-39, Chicago, Univ. Chicago Press.

Making a living—or living. 11 pp. New York, N. Y. Univ.

(With Harold C. Bryant, Hermon C. Bumpus, Vernon Kellogg, and Frank R. Oastler.) Reports with recommendations from the Committee on Study of Educational Problems in National Parks, January 9, 1929, and November 27, 1929. Privately printed, Wash.

The opportunities of the Federal government in research. Educ. Rec. (Wash.), vol. 11, no. 3, pp. 188-195.

The past as living. Sci. Mo., vol. 31, no. 4, pp. 340-343; Carn. Inst. Wash. N. S. Bull., vol. 2, no. 11, pp. 78-82.

Fossils from Rancho La Brea: "A classic of science." Sci. N. L. (Wash.), vol. 18, no. 505, pp. 378-380.

1931

Trends in graduate work. Univ. Iowa Studies, n.s., no. 194, ser. on Aims and progress of research, no. 33, pp. 75-81.

The unity of nature as illustrated by the Grand Canyon. Inaug. Bull., Univ. Ariz., pp. 21-32; Sci. Mo., vol. 33, no. 3, pp. 227-234.

1932

The search for spiritual leadership. Torch Mag. (Buffalo), vol. 5, no. 1, pp. 3-6.

The tree in the architecture of Washington. Amer. Forests (Wash.), Bicent. no., vol. 38, no. 2, pp. 76-80.

Science and city trees. Amer. Civic Ann., vol. 4, pp. 205-207.

Remarks at Science Service Round-Table Conference, April 27, 1932. Sci., n.s., vol. 76, no. 1964, p. 155.

Educational values of recreation. Educ. Rec. (Wash.), vol. 13, no. 4, pp. 253-256.

Foreword to pamphlet describing 1932 exhibition, Carnegie Institution of Washington. Exhibition representing results of research activities of the Carn. Inst. Wash., Dec. 10-12, 1932, p. 6.

Parks: national and state. 19 pp. Privately printed, Wash., D. C.

(With Chester Stock.) The Felidae of Rancho La Brea. Carn. Inst. Wash. Publ. 422. xvi + 231 pp.

1933

Spiritual values and the constructive life. The obligation of universities to the social order, edited by Henry Pratt Fairchild, pp. 317-331. N. Y., N. Y. Univ. Press.

Remarks introducing Alfred Noyes. The obligation of universities to the social order, edited by Henry Pratt Fairchild, pp. 351-352. N. Y., N. Y. Univ. Press.

Evolution of society as influenced by the engineer. Elect. Eng. (N. Y.), vol. 52, no. 3, pp. 171-173.

Science and government. First Interstate Legislative Assembly Jour., pp. 21-22.

Introductory remarks (Symposium on Climatic Cycles, annual meeting of National Academy of Sciences, April 26, 1932.) Nat. Acad. Sci. Proc., vol. 19, no. 3, pp. 349-350.

Reality in adult education. Journ. Adult Educ., vol. 5, no. 2, pp. 141-142.

Science and the constructive life. Univ. Va. Alumni News, vol. 21, no. 7, pp. 153-158.

Charts and compasses. Carn. Mag., vol. 7, no. 3, pp. 75-80.

Human values in natural resources. Educ. Rec. (Wash.), vol. 14, no. 3, pp. 296-300; reprinted in revised and abridged form, Nat. Parks Bull. (Wash.), vol. 13, no. 61, pp. 5-6.

Crater Lake: a study in appreciation of nature. Amer. Mag. Art, vol. 26, no. 8, pp. 357-361.

A brief guide to the parapet views, Sinnott Memorial, Crater Lake National Park. 8 pp. Wash. Carn. Inst. Wash.

(With Chester Stock.) Tertiary mammals from the auriferous gravels near Columbia, California. Carn. Inst. Wash. Publ. 440, paper I, pp. 1-6.

The constructive element in education. 47th Ann. Conv. Middle States Assn. Coll. & Secondary Schools, Dec. 1-2, 1933 (Atlantic City) Proc., pp. 33-39.

1934

Conservation and evolution in a changing social program. Amer. Phil. Soc. Proc., vol. 73, no. 5, pp. 351-370.

Science and conservation. Sci. n.s., vol. 79, no. 2057, pp. 496-497.

The responsibility of science with relation to governmental problems. Berkeley Daily Gazette (June 21).

Present status of knowledge relating to antiquity of man in America. (With list of references compiled by Frank H. H. Roberts, Jr.) Preprint of Rept. XVI Inter. Geol. Cong. (Wash., 1933), pp. 1-11; under the title "Early Man in America," with slight revisions. Carn. Inst. Wash. N. S. Bull., vol. 3, no. 23, pp. 183-190; Rept. XVI Inter. Geol. Cong. (Wash., 1933), vol. 2, pp. 1313-1323 (1936).

The inquiring mind in a changing world. Rice Inst. Pamph., vol. 21, no. 3, pp. 194-206.

Scientist in an unscientific society. Sci. Amer., vol. 151, no. 2, p. 79.

Letter addressed to William H. Welch regarding Clifford Beers and the work on mental hygiene. Twenty-five years after: sidelights on the mental hygiene movement and its founder, edited by Wilbur L. Cross, pp. 254-255. N. Y., Amer. Found. Mental Hygiene.

Some responsibilities of science with relation to government. Sci., n.s., vol. 80, no. 2087, pp. 597-601.

1935

An American fireside. Mimeographed, 10 pp.

——— Foreword. Science and the public mind, by Benjamin C. Gruenberg, pp. v-vii. N. Y., McGraw-Hill.

Ultimate values of science. Carn. Inst. Wash. Suppl. Publs., no. 15, 8 pp.

Early man in America. Carn. Inst. Wash. N. S. Bull., vol. 3, no. 23, pp. 183-190.

Remarks of the President of the Carnegie Institution of Washington before the Board of Trustees at the annual meeting on December 14, 1934. Printed by request of the Board of Trustees. Confidential edit., 29 pp. Wash. Carn. Inst. Wash.

Foreword to first and second Elihu Root lectures. Elihu Root lectures Carn. Inst. Wash. on the influence of science and research on current thought, pp. iii-v. Wash. Carn. Inst. Wash.

Geography and history among the sciences, in research on the Americas. Mimeographed, 12 pp.; Spanish edit., mimeographed, 11 pp.

The origin of Henry van Dyke's poem on the Grand Canyon. "History and exploration of the Grand Canyon region," Nat. Hist. Bull., no. 2, Grand Canyon Nat. Hist. Assn., pp. 7-9.

1936

Science and human values. 11 pp. N. Y., The Amer. Inst.

Time and change in history. Time and its mysteries, ser. I, pp. 23-26. N. Y., N. Y. Univ. Press.

Shelley and men of science. Christian Register (Boston), vol. 116, no. 45, pp. 747-749.

1937

The most important methods of promoting research, as seen by research foundations and institutions. Amer. Phil. Soc. Proc., vol. 77, no. 4, pp. 605-608.

Conservation and national policies. Mimeographed, 6 pp.

Geography and history among the sciences, as influencing research in the Americas. 2nd Gen. Assemb. Pan-Amer. Inst. Geol. & Hist. (Wash., Oct. 14-19, 1935) Proc., Dept. State Conf. ser. no. 28, pp. 291-301; Spanish translation, pp. 302-314. Wash., Govt. Print. Office.

The relation of science to technological trends. In Report of Subcommittee on Technology, National Resources Committee, June 1937. Technological trends and national policy including the social implications of new inventions, part two, "Science and technology", sect. I, pp. 91-92. Wash., Govt. Print. Office.

Palaeontology of early man (Introductory remarks before International Symposium on Early Man, Academy of Natural Sciences of Philadelphia, Mar. 17, 1937.) Pan-Amer. Geol., vol. 68, no. 1, pp. 1-3.

Opening the auditorium and exhibits building of the Mount Wilson Observatory: Part I, Interpreting the results of research. Carn. Inst. Wash., N. S. Bull., vol. 4, no. 21, pp. 183-187.

1938

Application of science in human affairs. Carn. Inst. Wash. Suppl. Publs., no. 42, 11 pp.

Influence of science upon appreciation of nature. Univ. State N. Y. Bull. 1143, pp. 11-21; Carn. Inst. Wash. Suppl. Publs., no. 44, 11 pp.

Some aspects of cooperative research in history. Carn. Inst. Wash. Suppl. Publs., no. 45, 13 pp.

1939

Contribution of geology to shaping of ideas on the meaning of history. Geol. Soc. Amer. Bull., vol. 50, pp. 443-448.

Development of cultural and social values through the relation of science to other major fields of activity. Grad. School, Dept. Agr., Wash. Mimeographed, pp. 25-47.

Palaeontological, geological, and historical research. Carn. Inst. Wash. Year Book 38, pp. 301-310.

1940

(And associates.) Palaeontological, geological, and historical research. Carn. Inst. Wash. Year Book 39, pp. 290-312.

The value of a birthday: message on occasion of the 375th birthday of Saint Augustine. St. Augustine Record, p. 15 (Sept.)

1941

(And associates.) Palaeontological, geological, and historical research. Carn. Inst. Wash. Year Book 40, pp. 316-333.

Responsibility of science in planning for a new world order. Proc. Dedicatory Exercises, The Allan Hancock Foundation for Sci. Research, Univ. So. Calif., 6 pp.

Cultural objectives as a basis for international understanding. L. A. Daily Journ., Aug. 21.

Origin and evolution of cultures in America—Common interests in nature expressed by peoples of America. Pan-Amer. Inst. Geol. & Hist. Proc.

1942

Palaeontological, geological, and historical research. Carn. Inst. Wash. Year Book 41, pp. 284-297.

The highest uses of the redwoods. Messages to the Council of the Save-the-Redwoods League, 1922-1941. Published by the Save-the-Redwoods League, pp. 1-39.

1943

The garment of God. 162 pp., N. Y., Charles Scribner's Sons.

H Gideon Wells

HARRY GIDEON WELLS

1875–1943

BY ESMOND R. LONG

Harry Gideon Wells was born at Fair Haven, a suburb of New Haven, Connecticut, on July 21, 1875. He came from substantial Puritan stock on both sides of his family. His progenitors were English as far back as there was any record. His most distinguished ancestor was Thomas Welles, second Governor of Hartford Colony. He was related to but not directly descended from Gideon Welles, Secretary of the Navy in Lincoln's cabinet. Some branches of the family used the spelling Welles. The name Gideon recurred frequently.

His father was Romanta Wells. His grandfather also had this curious given name, which appears to have had some special significance for H. Gideon Wells' great grandmother. Romanta Wells had intended to study medicine, and, as a preparation, at the age of fourteen, started an apprenticeship in a Hartford drugstore. In the early sixties he moved to Fair Haven to work in a larger store. He later bought a drug store of his own, and shortly afterwards married the daughter of a neighbor, Emma Tuttle. The plan to study medicine never materialized and Romanta Wells remained in either the retail or wholesale drug business all the rest of his life. The Tuttles were described by Gideon Wells as conservative farming people, landloving, churchgoing and moderately prosperous.

School and College

Young Harry Wells went to several grade schools in Fair Haven and the New Haven into which Fair Haven was eventually absorbed. By his own account his grades were good except in conduct, and, like many other men who ultimately achieved distinction, he was suspended from school—in his case briefly —for a schoolroom prank.

After he learned to read, the major part of his education was derived from his independent efforts. He read everything in the house, including all of Appleton's Encyclopedia, and much of it several times. This taste persisted and his knowledge of current literature in his later years was extraordinary.

He entered Hillhouse High School, the only high school in New Haven, in 1889, choosing the scientific rather than the classical curriculum, a three-year course recognized as preparing for the Sheffield Scientific School. Even at that early date he intended to be a doctor. He was at least as much interested in athletic sports at the time, and for two years of his high school course was sports writer for a local paper.

While he was in high school the family moved from the Fair Haven home to a house on Trumbull Street in New Haven, a remarkable location from an academic point of view, for on this street, in the short space of one block, lived Samuel W. Johnson, founder of agricultural chemistry in America, and the distinguished biological chemists, Russell H. Chittenden, Lafayette B. Mendel and Thomas B. Osborne. At the time, however, Wells was more interested in the Yale athletic heroes, with one of whom, Amos Alonzo Stagg, he later came to be intimately associated at the University of Chicago.

Wells entered the Sheffield Scientific School of Yale University in the fall of 1892 after graduating from the Hillhouse High School of New Haven, "without honors or complaints," according to his own statement. In his third year he took a course in biochemistry under Chittenden and Mendel which he described fifty years later, after a lifetime of critical analysis of teaching, as "the best organized and most thorough course I ever took," which "served as the basis and background" for the rest of his life's work.

Earlier in the curriculum he had studied paleontology with Othniel C. Marsh, who was famous as the discoverer of important stages in the evolution of the horse, but who was admired particularly by the students as the personal and intimate friend of Buffalo Bill, who had been Marsh's guide in the Dakota Bad Lands. Wells had courses under other distinguished teachers, but it was Mendel, principally, who developed his interest and capacity. Wells wrote "he was one of the greatest teachers I ever knew. I adored him as a student, worked with him whenever I could, and felt as if he were my big brother when I went for advice." In the shuffle of assignments, Wells prepared his thesis under Sidney Smith, professor of zoology. The thesis was an ambitious study of comprehensive scope entitled "The Comparative Anatomy of the Bile Tracts of Carnivora, Herbivora, and Omnivora."

Yale University and the Sheffield Scientific School remained a second home for Wells all his life. He returned frequently for study with Mendel during vacation periods from the University of Chicago, and occasionally collaborated with others of the distinguished faculty there or in summer months at Woods Hole. He developed especially fruitful associations with Frank P. Underhill and Thomas B. Osborne.

Medical School

The depression of the early nineties, which forced Wells' father out of business in New Haven, was responsible for Wells' settlement in Chicago. In the summer of 1893 Wells' father and mother visited the Chicago Worlds Fair. In Chicago, Wells Sr. saw new opportunity and purchased a retail drug business on the West Side in a location close to Rush Medical College. Wells spent the summer of 1894 in Chicago, and actually, before his graduation at Yale, began his study of medicine that summer. His father's store was also the office of a unique character in surgery in the Middle West, Dr. E. W. Lee, the preceptor of the still more famous surgeon John B. Murphy. Lee's son, a practicing physician, took Wells on horse-and-buggy rounds and both of them assisted Murphy in experimental surgery. Wells' mind was made up; only the choice of a medical school remained. There were three good ones in Chicago, and on the advice of Murphy he chose Rush Medical College.

He still had to return to New Haven for his final year at Sheffield Scientific School. He graduated in 1895, not yet 20 years old. He spent the summer in Connecticut, much of it in the companionship of a cousin by marriage, Bertha Robbins, the future Mrs. Wells.

In September 1895 he returned to Chicago to commence his course at Rush. By fortunate chance he resided in a boarding house where Dr. and Mrs. Norman Bridge took their meals.

Bridge was a member of a famous group which included James B. Herrick, Frank Billings, Nicholas Senn, James N. Hyde, Bertram Sippy, Walter Haines and Ludvig Hektoen. Learning of Wells' previous training in biology, Bridge introduced Wells to Hektoen, and so began an association close, fruitful, and without interruption to Wells' dying day.

Wells went through the grueling course at Rush with distinction, "made County," finishing second in the severe competitive examination for the Cook County Hospital interneship, and later was appointed Fellow in Pathology under Hektoen at Rush. With him, in a similar position, was Howard T. Ricketts, who later discovered the "rickettsiae." By that time both were veteran investigators. Wells had worked on "Fourth of July tetanus" and Ricketts on the etiology of skin infections. Wells had won the Benjamin Rush Medal with a paper on "The Physiology and Therapeutics of the Thyroid Gland and its Congeners," which was published in the Journal of the American Medical Association and brought a characteristic short complimentary note from William Osler in Baltimore. His most notable research accomplishment was the independent discovery of the etiology of blastomycetic dermatitis. Gilchrist of Baltimore had already described two cases, however, in a paper Wells had not yet seen.

Post Graduate Study

The fellowship in pathology did not provide a living, and Wells supplemented his three-hundred-dollar salary by tutoring, conducting quiz classes, and for a short time only, by the practice of medicine. He took the practice of a well-known, aging Chicago physician, Henry M. Lyman, and held it without great interest or success for a little more than a year, relinquishing it to accept an offer as assistant to Hektoen in the Department of Pathology in the rapidly developing medical school of the University of Chicago, with which Rush Medical College had become affiliated.

His formal education was not yet completed, however. At Chicago, whenever he had time, he took courses in chemistry under Julius Stieglitz, for whom he developed deep admiration and affection. From then on his work in pathology was always influenced by his understanding and appreciation of chemical processes.

On April 2, 1902 he married his Connecticut companion and friend Bertha Robbins. Two years later, after promotion and an increase in salary, he and Mrs. Wells left for a year of study abroad. Landing in Italy, they toured through Switzerland and much of Germany before reaching their destination, Berlin. On the way Wells visited many of the most celebrated German medical investigators, including Ziegler, von Recklinghausen, Kossel, Marchand and Ehrlich. He was now an assistant professor, traveling in a land showing profound respect for academic rank. In Berlin he entered the laboratories of Ernst Salkowski, the leading and almost only chemical pathologist of the time. Here he commenced his ultimately well-known studies on calcification. It was only an interim occupation, however. His real objective was Emil Fischer's laboratory, which he entered after a few weeks of waiting. He was doubly fortunate in his assignment, which was in Fischer's own room, under the immediate supervision of Emil Abderhalden. Others in the room included two future Nobel Prize winners, Fritz Pregl and Otto Warburg. Wells developed a profound admiration for Fischer, whom he considered "the greatest chemist who ever lived." Fischer was then finishing his monumental work on the proteins. Each student in the laboratory was assigned an analytic problem in the field. Two of Wells' good friends from Chicago were there at that time; in describing their work Wells wrote "Le Count got goose feathers, Herrick got fish scales and I analyzed horse hair."

In Berlin Wells took advantage of the city's extraordinary wealth of scientific meetings. On one occasion he heard the epoch-marking paper by Schaudinn on the discovery of the spirochete of syphilis.

In Paris, on the way home, at the instigation of the American consulate, which had learned that an American pathologist was there on a visit, Wells assisted in the identification of the brandy-preserved remains of John Paul Jones, who had been buried obscurely in the city a hundred years before. Wells corroborated a French pathologist's diagnosis of chronic nephritis in the shrunken kidneys, a disease from which Jones was suspected to have suffered in his last years. It must have been with great satisfaction that Wells watched the elaborate parade down the Champs Élysées that preceded the return of the immortal admiral to the United States.

Research

Back in Chicago in 1905 Wells entered on his most productive period. Hektoen was his chief, but was fully occupied with his continuing duties at Rush Medical College. Ricketts held a position like that of Wells, but was out of residence most of the time, so that Wells had a free hand in developing the new department.

The faculty was a distinguished one, with such men as Franklin P. Mall and Llewellys Barker in anatomy, Jacques Loeb and later A. J. Carlson in physiology, A. P. Matthews in biological chemistry, Edwin O. Jordan in bacteriology, and Waldemar Koch, nephew of the great bacteriologist Robert Koch, in pharmacology. Wells and Koch were particularly close until the latter's untimely death in 1911.

In the years from 1905 to World War I Wells made the investigations that led to his general acceptance as the country's chief authority on the chemical aspects of pathology and immunology. A research on fat necrosis, which resulted in a clear understanding of this condition, was counted as fulfilling requirements for a Ph.D degree in pathology. This was followed by a series of papers in the general field of autolysis, which did much to establish the fundamental nature of degenerative processes and tissue necrosis, as well as such practical matters as the differential staining of tissues in these abnormal states. Mendel's influence was evident here. Mendel had put him to work on a problem of purine metabolism in the mollusc, and Wells capitalized on the results by applying them to a variety of pathological problems in man. Many of his students were assigned problems in the same field.

A problem of great interest to Wells was the evolutionary development of the purine enzymes in animals. Man, unlike most animals, does not possess the enzymes necessary for oxidation of uric acid to allantoin, a deficiency predisposing him to uric acid calculi in the kidneys and the metabolic disorder gout. Using animals from the New York Zoological Park, furnished him from time to time by its Director, Dr. W. T. Hornaday, Wells discovered that the higher primates, i. e., the chimpanzee and orang-outang, but not the smaller monkeys, resembled man in their lack of the enzyme uricase.

In Chicago Wells continued studies on calcification that he had commenced with Salkowski, and published particularly noteworthy papers on metastatic calcification, which led, in 1911, to an invitation to give a lecture on the general problem of pathological calcification before the Harvey Society in New York.

An ingenious investigation by Wells removed certain misunderstandings with respect to the phenomenon of fatty degeneration of the liver. This degenerative process was thought to be due in part to the inability of the liver to carry out its normal oxidizing processes. Using hydrazine, introduced in experimental pathology by Underhill, to damage the liver lobule centers, and phosphorus to injure the lobule peripheries, he caused a profound fatty degeneration of the liver in experimental animals. Applying the standard test for the presence of the oxidizing enzyme for uric acid he found to his surprise that that oxidative mechanism, at least, was still intact.

These and other studies laid the foundation for his well-known *Chemical Pathology,* first published in 1907, which reached its fifth edition in 1925. Wells followed a unique method in preparing this book, the original stimulus for which he attributed to Hektoen, to whom the book was dedicated. He was a prodigious reader of the literature and collector of the latest information in the many fields of his specialty. Whenever he encountered a problem on which he felt he could not write satisfactorily he initiated a research upon it. His growing book guided him into many of his studies, including autolysis, calcification, fatty metamorphoses, lipases and differential necrosis in parenchymatous organs.

A series of investigations of great importance for immunology were carried out in collaboration with the distinguished protein chemist Thomas B. Osborne. Using the technic for anaphylaxis in the guinea pig, sensitizing them with Osborne's pure vegetable proteins, and challenging the animals with the same or related proteins, Wells established the dependence of specificity in reaction on the chemical nature of proteins rather than their biologic origin.This work led to the second of his three books, on *The Chemical Aspects of Immunity*, first published in 1925, with a second edition in 1929, which was translated into German, French, Russian and Roumanian.

His third book, *The Chemistry of Tuberculosis,* with Lydia DeWitt and Esmond R. Long as co-authors, was the outgrowth of a series of investigations under the sponsorship of the Otho S. A. Sprague Memorial Institute, an organization established in 1911 by A. A. Sprague of Chicago, under the terms of the will of his brother Otho S. A. Sprague, a Chicago capitalist. On the advice of Dr. Frank Billings, a member of the Board of Directors of the new organization, the income from its endowment was used for medical research, and Wells was named the first Director. With funds available for assistants he promptly instituted a series of investigations in several fields. One of special importance was the chemotherapy of tuberculosis. The stimulus for this came from Ehrlich's discovery in 1909 of salvarsan and its effect on syphilis. With salvarsan as a model Wells put Dr. DeWitt on a long and ultimately deeply disappointing research on the drug treatment of tuberculosis. By coincidence Paul A. Lewis at the Henry Phipps Institute of the University of Pennsylvania was attacking the same problem by similar methods at the same time. Both used dyes having more or less capacity to penetrate the tubercle, the dyes carrying a combined metal, such as arsenic or mercury, or some other toxic radical as a bactericidal agent for the tubercle bacillus. These two patient and unsuccessful investigations served one great purpose, the refutation of extravagant claims abroad for numerous products put forth on a commercial basis as cures for tuberculosis.

In the current (1949) encouraging development of chemotherapy of tuberculosis, William H. Feldman, one of the earliest investigators of streptomycin, recalled a statement made by

Wells, at the conclusion of this long and fruitless research, that the chemotherapy of tuberculosis must await the development of new principles. These have perhaps been discovered in the use of the sulpha drugs and antibiotics.

The Sprague Institute was concerned with many investigations besides that on tuberculosis. Laboratories were established at Rush, where R. T. Woodyatt worked on diabetes, and in the Children's Hospital on Chicago's North Side, where fundamental studies were made on pediatric problems by H. F. Helmholz, Samuel Amberg, C. A. Aldrich and others. Probably the most exciting study in the Institute, however, was a long investigation by Maud Slye on the genetics of cancer. As a student of Professor C. O. Whitman of the Department of Zoology, Miss Slye had noted the frequent occurrence of cancer in certain inbred strains of mice. Wells gave her an opportunity to breed mice on an enormous scale in an investigation which lasted from 1911 to 1942. A great and historic controversy, which raged at meetings of the American Association of Pathologists and Bacteriologists and the American Association for Cancer Research, developed between Miss Slye and Clarence C. Little of the University of Michigan, later of Bar Harbor, who was conducting similar investigations, and whose intrepretations of the phenomena of inheritance of cancer differed radically from those of Miss Slye. Wells championed Miss Slye most forcefully. His part in the investigation was the diagnosis of the developing tumors, hers the selective breeding of the animals. After thirty years he was willing to admit that Miss Slye must have been wrong in many of her concepts, but to the end he gave her the principal credit in this country for establishing the fact of inheritability of cancer, whatever its exact mechanism might be.

These were only a part of Wells' studies on cancer. His semiweekly autopsies at the County Hospital and later autopsies at the Albert Merritt Billings Hospital of the University of Chicago gave him abundant material for study. He was so well known by that time as a chemical pathologist that it was often overlooked that he was a general pathologist and morbid anatomist of the first rank. He was one of a small but distinguished group of pathologists in this country when American pathology was escaping from German tradition and becoming an independently American discipline. Wells, who never overlooked an opportunity for research in a chance discovery at an autopsy, and who combined detailed studies with broad perspective on the problem, contributed a large element of common sense to the increasingly complicated subject of cancer diagnosis.

His other researches in general pathology included studies of such diverse problems as waxy degeneration of muscle, primary cortical atrophy of the adrenal gland and post operative pulmonary embolism. The latter was rare in his County Hospital days, but all too frequent at Billings. He attributed its increase in incidence to improvement in surgery, pointing out that in the old days of inferior technic most blood clots at the site of operation were slightly infected and therefore inclined to adhere safely to their vessel walls.

He was at all times a prodigious worker, but never an impatient, hurried or self-pitying one. For years he worked in his laboratory or his office five nights a week and Sunday mornings. His assistants grew up with the idea that this was normal. But it was fun, not labor. Many nights Mrs. Wells came over and the two departed at 10:00 o'clock for the second feature of one of the local movies. Wednesday, his day for visiting the Sprague Institute laboratories on the North Side, was also his day for trap shooting at the Lincoln Park Gun Club, which was conveniently located near the Children's Hospital. After his autopsies at the County Hospital, while his assistants were cleaning up, he used to slip out the back door of the morgue and enter the Chicago Cub baseball park, across the road, where all cares were dropped. He was an expert student of the game, knew every player, and remembered all the scores.

Teaching

As a teacher he was superb, chiefly because he made every student work. He was a relentless quizzer, but enlivened every discussion with humor, sometimes caustic, always sparkling. He never lectured to students. He enjoyed teaching the first courses in pathology, but later, when his administrative duties were too heavy, transferred this responsibility to his assistants. He retained charge of the autopsy course, however, until his retirement. Students registered for it if they possibly could; his assistants took it as a matter of course. Hundreds of students remember "Path 3" as one of their most fascinating experiences in medical school. The members of the class, in rotation, "took" each autopsy, working up the case and cutting sections for the whole class. Diagnosis on class days had all the elements of an intriguing game.

Twenty-six students took a Ph.D. degree in pathology under Wells, a large number in a field where the M.D. degree is ordinarily considered sufficient. Many combined the research leading to the Ph.D. with the course for the M.D. degree. Some, but not many of these men, became general pathologists. Most entered special fields, as diabetes, nutrition, cancer and tuberculosis, their later interests reflecting spontaneous stimulation under Wells, or, not infrequently, an unrelated chance devolopment. Wells did not force these interests. What he said of Hektoen was eminently true of himself. Once, when asked the chief element of Hektoen's influence on young men, he said, "He encouraged individuality. He never tried to mould them to a pattern or impose his own upon them. He noted the strongest and best qualities in each and encouraged the men to develop them." In 1939 his students and friends arranged for a portrait by the Chicago artist Wayman Adams, which was presented to the University of Chicago in an official ceremony.

World War I. Roumania

The year 1917 brought about a profound change in Wells' life, as in that of countless others. In July of that war year, out of a clear sky, after searching elsewhere for opportunity to be of service, he was offered a commission in a Red Cross mission to Roumania, then struggling desperately against invading German forces, and suffering from a succession of epidemics of cholera, typhus and typhoid fevers and other infectious diseases, and a mounting toll from famine.

The mission left Vancouver, B. C. on August 1, arrived in Yokohama August 14, and after an extraordinarily interesting trip through Siberia and Russia during the Bolshevist revolution reached Jassy, Roumania, on September 16. The trip and the new responsibilities were unlike anything Wells had ever experienced. The mission arrived in that part of Roumania not overrun by the German Army at a time when at least half a million people had fled from Wallachia to Moldavia, together with nearly two million retreating Roumanian and Russian soldiers. Wells described them as a "horde of exhausted, demoralized, underclothed, underfed people crowded into a country unprepared in every way to rise to the situation." Remarkably, however, the epidemics, which were at their height when the mission was organized, had already waned considerably. Dangerous foci of infection remained, to be sure. Wells, together with Dr. Roger Perkins, Professor of Public Health of Western Reserve University, was assigned the task of making a survey of the medical state and needs of that portion of the country remaining in Roumanian hands. The tour, which took them from remote country districts to the front line of the Roumanian Army, made them familiar with diseases now almost unknown in the United States, of which typhus and typhoid fever were the most serious. Typhus was being brought under control, but they encountered many cases in hospitals throughout the small towns and not a few in the homes.

Typhoid fever was endemic, aided by a stupendous plague of flies. Vaccination was effective, however. Wells and Perkins discovered the interesting fact that the disease was more prevalent in Roumanian officers than privates. The explanation was that vaccination was compulsory for enlisted men but not for officers.

Malnutrition was widespread. Pellagra and nutritional edema were outstanding problems. Fortunately, within the preceding few years, knowledge of the deficiency diseases had developed greatly and the remedies were clear if not always available. The relation of a protein-low diet to the so-called war edema was becoming understood.

The recommendations of Wells and Perkins were approved and implemented by orders from the States which would have insured medical personnel and supplies. Unfortunately the

Russian collapse occurred at this time, and it became necessary for the mission to return to the United States—again by way of Siberia and the Orient, in a trip of surpassing geographical and political interest, which brought the party home in mid-December 1917.

Wells' experience with Roumania was far from concluded, however. In October 1918, Colonel Anderson, his chief on the first trip, asked him to join another mission to the Balkans, which now, after the German retreat from Greece and Siberia, could be reached from the Mediterranean. Wells accepted, and sailed from New York with the mission, after innumerable delays, on November 13. The armistice two days before had thrown all planning into confusion. In London and Paris an entire reorganization was affected, which resulted in Wells' appointment as chief of a Red Cross mission to Roumania with an unofficial position as liaison officer with the Food Administration, which, under Herbert Hoover, was engaged in fighting famine throughout eastern Europe. The responsibility for relief among 16,000,000 people and a budget of a million dollars, exercised in a maze of difficult diplomatic problems, was an exciting experience for a man with an almost exclusively academic background. He was an able administrator, however, and proved successful. The mission reached Galatz, Roumania in February 1919, where it was greeted by a cheering throng for whom the ship's stores spelled the end of famine. Warehouses were established and in spite of the most discouraging difficulties with transportation, medical supplies, food and other assistance soon streamed to the most distant parts of the country. Wells' recently acquired knowledge of the deficiency diseases was invaluable, and he himself learned much more in the course of his duties.

From a personal point of view the mission was of extraordinary color. He became familiar with Roumania and the surrounding countries and well acquainted with the Roumanian royal family, from whose hands he received the Star of Roumania. He returned to America in June 1919, as from another world, and took up the duties he had dropped two years before.

Recreation

Wells had a great and lasting interest in sports. Fishing was his favorite and perhaps his best, although he was expert in all to which he devoted himself. His graduate students will remember the seven-foot tarpon which adorned one wall of his office. He liked bass fishing best, however, and probably his happiest memories were of the September vacation periods he and Mrs. Wells spent at Tenderfoot Lake in northern Wisconsin, an isolated spot where they could relax completely, with fishing, canoeing, swimming and evenings of bridge, which they both enjoyed. He made occasional quick trips to the Mississippi River during the academic year, to fish for bass, and one of the most compelling inducements, when he was asked to accept a lecture engagement, was an opportunity for fishing or duck or quail hunting.

He was an excellent shot with any gun, and almost unbeatable in trap shooting. He made the varsity team in that sport at Yale. Trap shooting and golf were his chief forms of outdoor relaxation in Chicago. Even as a student at Rush he did a little shooting. He liked to recall that one day on a picnic he taught the little daughter of his landlady to shoot a .22 rifle, and that in later years, as Mary Hastings Bradley, she became a famous lion hunter. In his later years, even after heart trouble had greatly restricted his activities, he kept up his quail shooting, a sport he could enjoy because, as he said, he could sit on a stump and let the birds come to him.

He was a good golf player, and one who took the game with unusual seriousness. He was less skillful than at fishing and shooting, analyzed his mistakes with painstaking thoroughness, and had his son take movies of his stance and swing so that he could improve them. He played regularly with colleagues from Rush and a few of his graduate students, and there is no doubt that the sport helped to keep him in good physical condition.

Later Years

After the University of Chicago developed a four-year course in medicine in 1926, and the Pathology Department moved into handsome quarters adjacent to the Albert Merritt Billings Hospital, Wells' research and teaching were much curtailed. Administrative duties consumed most of his time and energy. His students made more autopsies than he, although he continued to direct and teach the autopsy class, and used the findings of many a unique autopsy for a significant pathological report. He spent an immense amount of time building a museum of gross pathological specimens, which would be the pride of any teaching institution.

He was active in the American Association of Pathologists and Bacteriologists, of which he was president in 1919, the American Association for Cancer Research, of which he was president in 1915 and 1919, the American Association of Immunologists, the American Society of Biological Chemists, the American Society for Experimental Pathology, and other professional societies in the fields of his special interests. The September-October number of the 1941 volume of the American Journal of Pathology, official publication of the American Association of Pathologists and Bacteriologists, which Wells served for many years as a member of the Editorial Board, was issued in his honor, and made up entirely of articles by his former students. He was elected to the National Academy of Sciences in 1925.

The last eleven years of his life were burdened by ill health. In February 1932 he had a sudden attack of what at first appeared to be a general myositis. In a few days it was all too evident that a major circulatory disturbance had occurred. His pulse slowed and after a time stabilized at just half its normal rate, where it remained for the rest of his life—a complete heart block. He spent many weeks in bed during a stormy period of convalescence, but ultimately acquired a reasonably good compensatory hypertrophy of the heart, so that he could return to his desk and a seminormal life. Within a few years, however, grave deterioration in hearing developed. It was the chief factor in reconciling him to retirement, which took place October 1, 1940. He could no longer quiz, as he had for 45 years, and felt that his teaching days were over. He was succeeded as head of the Department of Pathology by his colleague, Dr. Paul

R. Cannon, who had taken over many of the administrative responsibilities of the Department during Wells' illness.

In Florida in the early spring of 1943 symptoms of intestinal obstruction developed. He was too good a physician and pathologist not to recognize the underlying cause, and he and Mrs. Wells returned to Chicago for an operation for what he had correctly diagnosed as carcinoma of the cecum. Unfortunately his weakened heart proved unable to stand the strain of the operation. He died on April 26, 1943, at the Billings Hospital, to which he had given long and devoted service, at the age of 67.

Mrs. Wells maintained their home in Chicago for a time, and later returned to her old family homestead in Connecticut, where she and Gideon Wells had often met in their youth. Their only child, Gideon Robbins Wells, who graduated in medicine at Harvard University and served as a medical officer in the North African, Italian and Far Eastern theaters in the second world war, also took up his residence and the practice of medicine in Connecticut.

In applying chemical methods to the study of morbid processes Wells was a pioneer in the development of pathology. His *Chemical Pathology* was an outstanding contribution to the literature of medical science. After more than twenty years, although long out of date in its extensive list of references, it is still the standard work in its domain. Largely bibliographical, it is independent in its organization, and is responsible for an orderly division of chemical pathology into fields.

Remarkably, few of his graduate students have specialized in the chemical aspects of pathology. He was a wise teacher of general pathology who refrained from restricting his students' interests to his own specialty. Most of them have developed their own inclinations, and can readily see where Wells' encouragement stimulated their independent tastes in research. Medical students who attended Rush Medical College and the University of Chicago from 1898 to 1940 will never forget him, for he was one of the most colorful members of a conspicuously talented faculty.

His closest friends will always remember him for his tireless industry, his keen humor, his affectionate regard for family and friends, and his vivid interest in the work and play all around him.

KEY TO ABBREVIATIONS USED IN BIBLIOGRAPHY

Allg. mil-ärztl. Ztg., Wien = Allegemeine militärärztliche Zeitung
Am. J. Cancer = American Journal of Cancer
Am. J. Med. Sci. = American Journal of Medical Sciences
Am. J. Physiol. = American Journal of Physiology
Am. Med. = American Medicine
Am. Rev. Tuberc. = American Review of Tuberculosis
Ann. Int. Med. = Annals of Internal Medicine
Arch. Int. Med. = Archives of Internal Medicine
Arch. Neurol. Psychiat. = Archives of Neurology and Psychiatry
Arch. Path. = Archives of Pathology
Arch. Path. Lab. Med. = Archives of Pathology and Laboratory Medicine
Arch. Surg. = Archives of Surgery
Bull. Am. Acad. Med. = Bulletin, American Academy of Medicine
Cancer Res. = Cancer Research
Central. allg. Path. u. path. Anat. = Centralblatt für allgemeine Pathologie und pathologische Anatomie
Deut. Archiv. klin. Med. = Deutsches Archiv für klinische Medizin
Interstate Med. J. = Interstate Medical Journal
J. Am. Med. Assn. = Journal of the American Medical Association
J. Biol. Chem. = Journal of Biological Chemistry
J. Cancer Res. = Journal of Cancer Research
J. Exp. Med. = Journal of Experimental Medicine
J. Immunol. = Journal of Immunology
J. Indust. Hyg. = Journal of Industrial Hygiene
J. Infect. Dis. = Journal of Infectious Diseases
J. Lab. Clin. Med. = Journal of Laboratory and Clinical Medicine
J. Med. Res. = Journal of Medical Research
J. Path. Bacteriol. = Journal of Pathology and Bacteriology
J. Urol. = Journal of Urology
Med. News = Medical News
Med. Welt. = Medizinische Welt
N. Y. Med. J. = New York Medical Journal
Phila. Med. J. = Philadelphia Medical Journal
Physiol. Rev. = Physiological Reviews
Prac. Med. Surg. = Practical Medicine and Surgery
Proc. Am. Soc. Biol. Chem. = Proceedings, American Society of Biological Chemists
Proc. Soc. Exp. Biol. Med. = Proceedings, Society for Experimental Biology and Medicine
Reference Handbook Med. Sci. = Reference Handbook of the Medical Sciences
Surg. Gynec. Obst. = Surgery, Gynecology and Obstetrics
Trans. Chicago Path. Soc. = Transactions, Chicago Pathological Society

Trans. Med. Chirur. Fac. Md. = Transactions, Medical and Chirurgical Faculty of Maryland
Trans. Nat. Tuberc. Assn. = Transactions, National Tuberculosis Association
Yale J. Biol. Med. = Yale Journal of Biology and Medicine
Zeit. Chemoth. = Zeitschrift für Chemotherapie und verwandte Gebiete
Zeit. Immun. = Zeitschrift für Immunitätsforschung und experimentelle Therapie
Zeit. Krebs. = Zeitschrift für Krebsforschung
Zeit. physiol. Chem. = Zeitschrift für physiologische Chemie

BIBLIOGRAPHY OF H. GIDEON WELLS

1897

A case of congenital syphilis complicated by a mixed infection with the staphylococcus and streptococcus pyogenes. J. Am. Med. Assn., *28,* 688.

The physiology and therapeutics of the thyroid gland and its congeners. J. Am. Med. Assn., *29,* 897, 954, 1007.

1898

Preliminary report of a case of blastomycetic dermatitis. N. Y. Med. J., *67,* 427.

1899

The practical value of the determination of indicanuria. Western Clinical Recorder, *1,* 286.

1900

An experimental study of the origin of the epidemic of tetanus following July 4, 1899—Report of case with recovery. Phila. Med. J., *5,* 1377.

The present conception of the means of defense against bacterial invasion. Students Medical Society of Rush Medical College, Nov. 2, 1900.

1901

The pathology of active tuberculosis of the pericardium. J. Am. Med. Assn., *36,* 1451.

Fourth of July tetanus. Med. News., *78,* 854.

(With D. R. Brower) A periendothelioma of the dura mater involving the cranial nerves. Am. J. Med. Sci., *122,* 32.

Education in hospital and laboratory. Bull. Am. Acad. Med., *5,* 540.

Primary carcinoma of the liver. Trans. Chicago Path. Soc., *5,* 11.

1902

Reversibility of enzymes, and its applications to physiologic and pathologic processes. J. Am. Med. Assn., *38,* 220.

The pathology of the healed fibrous adhesions of the pericardium. Am. J. Med. Sci., *123*, 241.

Fatal pulmonary embolism during convalescence from a simple appendectomy. Trans. Chicago Path. Soc., *5*, 134.

Multiple primary malignant tumors: Report of a primary sarco-carcinoma in the thyroid of a dog, with mixed sarcomatous and carcinomatous metastases. J. Path. Bacteriol., *7*, 357.

1903

Experimental fat necrosis. Trans. Chicago Path. Soc., *5*, 198.

Experimental fat necrosis. J. Med. Res., *9*, 70.

Experimental cirrhosis of the liver in chronic albumose intoxication. Trans. Chicago Path. Soc., *5*, 240.

Studies in fat necrosis. Decennial Publications, University of Chicago, *10*, 27 pp.

The pathological anatomy of paratyphoid fever. Trans. Chicago Path. Soc., *6*, 20.

Fourth of July tetanus. Am. Med. *5*, 954.

Primary carcinoma of the liver. Am. J. Med. Sci., *126*, 403.

1904

(With L. O. Scott) The pathological anatomy of paratyphoid fever; report of a fatal case with bacteriological findings. J. Infect. Dis., *1*, 72.

On the relation of autolysis to proteid metabolism. Am. J. Physiol. *11*, 351.

Thyroid (section on). Reference Handbook of the Medical Sciences, new ed., *7*, pp. 770-780. Edited by Albert H. Buck. William Wood & Company, New York, N. Y.

Haemolysis (section on). Reference Handbook of the Medical Sciences, new ed., *8*, pp. 467-477. Edited by Albert H. Buck. William Wood & Company, New York, N. Y.

(With L. O. Scott) Zur pathologischen Anatomie des Paratyphus. Allg. mil.-ärztl. Ztg., Wien, 36-40.

Findings in a case of acute yellow atrophy of the liver. Trans. Chicago Path. Soc., *6*, 120.

(With M. Maver) Pseudoleukemia gastrointestinalis. Trans. Chicago Path. Soc., *6*, 147.

(With M. Maver) Pseudoleukemia gastrointestinalis. Am. J. Med. Sci. *128*, 837.

1905

Versuche über den Transport von jodiertem Fett bei Phosphorvergiftung. Zeit. physiol. Chem., *45*, 412.

(With P. Bassoe) Acute yellow atrophy of the liver. J. Am. Med. Assn. *44*, 685.

(With E. Abderhalden) Die Monoaminosäuren des Keratins aus Pferdehaaren. Zeit. physiol. Chem., *46*, 31.

Pathologic calcification. Trans. Chicago Path. Soc., *6,* 361.

Malignant renal hypernephroma with vertebral involvement. Trans. Chicago Path. Soc., *6,* 375.

1906

A note on the cause of the anatomic and chemical changes observed in delayed chloroform poisoning and allied conditions. Trans. Chicago Path. Soc., *6,* 403.

Delayed chloroform poisoning: allied conditions; a note on the cause of the anatomic and clinical changes observed. J. Am. Med. Assn., *46,* 341.

Pathological calcifications. J. Med. Res., *14,* 491.

The relation of autolysis to the histologic changes occurring in necrotic areas. Trans. Chicago Path. Soc., *6,* 441.

The relation of autolysis to the histological changes occurring in necrotic areas. J. Med. Res., *15,* 149.

(With C. J. Rowan) The healing of suppurative appendicitis with calcification. Surg. Gynec. Obst., *3,* 503.

1907

Chemical Pathology. W. B. Saunders Co., Philadelphia, Pa., 549 pp.

(With L. B. Mendel) On absorption from the peritoneal cavity. Am. J. Physiol. *18,* 163.

(With R. L. Benson) The relation of the thyroid to autolysis, with a preliminary report on the study of autolysis by cryoscopic and conductivity determinations. Trans. Chicago Path. Soc., *7,* 20.

(With R. L. Benson) The relation of the thyroid to autolysis, with a preliminary report on the study of autolysis by determinations of the changes in freezing point and electrical conductivity. J. Biol. Chem., *3,* 35.

(With R. L. Benson) Studies on calcification and ossification II. J. Med. Res., *17,* 15.

The chemical composition of the liver in acute yellow atrophy. J. Biol. Chem., *3,* xv.

The chemistry of the liver in acute yellow atrophy. J. Exp. Med., *9,* 627.

The development of the Chicago Pathological Society. Presidential address. Trans. Chicago Path. Soc., *7,* 69.

(With O. P. Johnstone) On the route of absorption of bacteria from the peritoneal cavity. J. Infect. Dis., *4,* 582.

1908

The fats and lipoids of malignant renal hypernephromas. Proc. Am. Soc. Biol. Chem., *4,* xxii.

The fats and lipoids of malignant renal hypernephromas. J. Med. Res., *17,* 461.

The present status of our knowledge of the chemistry of the processes of immunity. Arch. Int. Med., *1,* 262.

The nature of the poisonous element of proteins that is concerned in the reaction of hypersensitization. J. Am. Med. Assn. *51,* 527.

Atypical forms of malignant renal hypernephromata with consideration of their chemical characteristics. International Clinics, *2,* 272.

The chemistry of malignant renal hypernephromas. Trans. Chicago Path. Soc., *7,* 152.

The pathological anatomy of hydrazine poisoning. J. Exp. Med., *10,* 457.

Chloroform necrosis of the liver. Arch. Int. Med., *1,* 589.

Autolysis (section on). Reference Handbook of the Medical Sciences, Revised to date. Appendix to *8,* pp. 402-405. Edited by Thomas L. Stedman. William Wood & Company, New York, N. Y.

Studies on the chemistry of anaphylaxis. Proc. Soc. Exp. Biol. Med., *6,* 1.

Studies on the chemistry of anaphylaxis. J. Infect. Dis., *5,* 449.

Persistent patency of the ductus arteriosus. Am. J. Med. Sci., *136,* 381.

The chemistry of the liver in chloroform necrosis (Delayed chloroform necrosis). J. Biol. Chem., *5,* 129.

Leiomyoma of the kidney of a horse. Trans. Chicago Path. Soc., *7,* 140.

1909

The pathogenesis of waxy degeneration of striated muscles (Zenker's Degeneration). J. Exp. Med., *11,* 1.

(With L. B. Mendel) Experimental studies on the physiology of the molluscs. Am. J. Physiol., *24,* 170.

The resistance of the human body to cancer. J. Am. Med. Assn., *52,* 1731.

Hemorrhagic infarction of the kidneys of the newborn. Trans. Chicago Path. Soc., *7,* 242.

Comparative physiology of nuclein metabolism. Trans. Chicago Path. Soc., *7,* 244.

(With H. J. Corper) Observations on purine metabolism. Trans. Chicago Path. Soc., *8,* 15.

Studies on the chemistry of anaphylaxis. II. J. Infect. Dis. *6,* 506.

Observations on uricolysis with particular relation to the pathogenesis of "uric acid infarcts" in the kidneys of the newborn. J. Biol. Chem., *6,* 321.

Observations on alimentary albuminuria by means of the anaphylaxis reaction. J. Am. Med. Assn., *53,* 863.

(With J. R. Greer) The absence of adrenalin in malignant renal hypernephromas. Arch. Int. Med., *4,* 291.

(With H. J. Corper) The purines and purine metabolism of the human fetus and placenta. J. Biol. Chem., *6,* 469.

1910

The purine metabolism of the monkey. J. Biol. Chem., *7,* 171.

Some recent additions to our knowledge of purine metabolism, and their bearing on the problems of gout. International Clinics, *20,* 76.

The presence of iodine in the human pituitary gland. J. Biol. Chem., *7,* 259.

(With R. L. Benson) The study of autolysis by physico-chemical methods. II. Proc. Soc. Exp. Biol. Med., *7,* 6.

(With R. L. Benson) The study of autolysis by physico-chemical methods. II. J. Biol. Chem., *8,* 61.

(With J. H. Mitchell) Studies on calcification and ossification. III. J. Med. Res., *22,* 501.

The relation of fatty degeneration to the oxidation of purines by liver cells. J. Exp. Med., *12,* 607.

1911

(With T. B. Osborne) The biological reactions of the vegetable proteins. I. Anaphylaxis. J. Infect. Dis., *8,* 66.

Calcification and ossification. Arch. Int. Med., *7, 721.*

Studies on the chemistry of anaphylaxis. Experiments with isolated proteins, especially those of the hen's egg. J. Infect. Dis., *9,* 147.

(With H. F. Holmes and G. R. Henry) Studies on calcification and ossification. IV. J. Med. Res., *25,* 373.

1912

(With H. F. Holmes and G. R. Henry) Experimental calcification of the kidney. Trans. Chicago Path. Soc., *8,* 251.

The fat metabolism of lipomas. Arch. Int. Med., *10,* 297.

Anaphylaxie und wachsartige Degeneration der Muskeln. Central. allg. Path. u. path. Anat., *23,* 945.

(With O. F. Hedenburg) Studies on the biochemistry and chemotherapy of tuberculosis. I. The permeability of tubercles for iodin compounds and proteins. J. Infect. Dis., *11,* 349.

(With H. J. Corper) The lipase of bacillus tuberculosis and other bacteria. J. Infect. Dis., *11,* 388.

The purines and purine enzymes of tumors. Trans. Chicago Path. Soc., *8,* 250.

The biochemistry and chemotherapy of tuberculosis. Trans. Chicago Path. Soc., *8,* 345.

1913

(With E. R. Long) The purines and purine metabolism of tumors, and the chemical relations of primary and secondary tumors. Zeit. Krebs., *12,* 598.

(With H. J. Corper and L. M. DeWitt) The effect of copper on experimental tuberculous lesions. J. Am. Med. Assn., *60,* 887.

(With T. B. Osborne) Is the specificity of the anaphylaxis reaction dependent on the chemical constitution of the proteins or on their biological relations? J. Infect. Dis., *12,* 341.

The relation of specificity to the chemical composition of proteins. Trans. Chicago Path. Soc., *9,* 38.

(With F. P. Underhill and S. Goldschmidt) A note on the fate of tartrates in the body. J. Exp. Med., *18,* 317.

(With F. P. Underhill and S. Goldschmidt) Tartrate nephritis, with especial reference to some of the conditions under which it may be produced. J. Exp. Med., *18*, 322.

(With F. P. Underhill and S. Goldschmidt) A study of renal secretion during tartrate nephritis. J. Exp. Med., *18*, 347.

Nucleo-proteins as antigens. Zeit. Immun., *19*, 599.

1914

(With G. C. Lake and T. B. Osborne) The immunological relationship of hordein of barley and gliadin of wheat as shown by the complement fixation, passive anaphylaxis, and precipitin reactions. J. Infect. Dis., *14*, 364.

(With T. B. Osborne) The anaphylactogenic activity of some vegetable proteins. J. Infect. Dis., *14*, 377.

The chemotherapy of tuberculosis. Interstate Med. J., *21*, 221.

(With L. DeWitt and H. J. Corper) Studies on the chemotherapy of tuberculosis. Zeit. Chemoth., Bd. II, Orig. 110.

(With G. T. Caldwell) The purine enzymes of the orang-utan (Simia Satyrus) and chimpanzee (Anthropopithecus Troglodytes). J. Biol. Chem., *18*, 157.

The purine enzymes of the anthropoids and marsupials. Proc. Soc. Exp. Biol. Med., *11*, 153.

(With M. Slye and H. F. Holmes) The primary spontaneous tumors of the lungs in mice. Trans. Chicago Path. Soc., *9*, 179.

(With M. Slye and H. F. Holmes) The primary spontaneous tumors of the lungs in mice. J. Med. Res., *30*, 417.

(With G. T. Caldwell) The inhibition of autolysis by alcohol. J. Biol. Chem., *19*, 57.

(With G. T. Caldwell) The purine enzymes of the opossum (Didelphis Virginiana). J. Biol. Chem., *19*, 279.

(With G. T. Caldwell) The comparative physiology of purine metabolism. Trans. Chicago Path. Soc., *9*, 155.

The relations between the scientist, the physician and the public. Alcalde, *2*, 928.

(With E. R. Long) Über die Purinenzyme der pneumonischen Lunge. Deut. Archiv. klin. Med., *115*, 377.

Chemical Pathology. W. B. Saunders Co., Philadelphia, Pa., 2nd ed., 616 pp.

Nucleoproteins as antigens. Trans. Chicago Path. Soc., *9*, 77.

Metastatic calcification. Trans. Chicago Path. Soc., *9*, 208.

1915

Metastatic calcification. Arch. Int. Med., *15*, 574.

(With A. L. Cameron) The origin of the proteins of nephritic urine. Arch. Int. Med., *15*, 746.

(With T. B. Osborne) The anaphylactic reaction with so-called proteoses of various seeds. J. Infect. Dis., *17,* 259.

Some features of purine metabolism. J. Lab. Clin. Med., *1,* 164.

1916

(With M. Slye and H. F. Holmes) Primary spontaneous tumors of the liver in mice. J. Cancer Res., *1,* 107.

(With T. B. Osborne) Anaphylaxis reactions between proteins from seeds of different genera of plants. J. Infect. Dis., *19,* 183.

The accumulation of uric acid in the tissues during suppression of urine. J. Biol. Chem., *26,* 319.

(With O. F. Hedenburg) The toxicity of carotin. J. Biol. Chem., *27,* 213.

Spontaneous sarcoma in mice. Trans. Chicago Path. Soc., *10,* 108.

(With M. Slye and H. F. Holmes) Spontaneous sarcoma in the mouse. J. Cancer Res., *1,* 360.

(With C. Watts) A case of generalized oidiomycosis, associated with pulmonary and laryngeal tuberculosis. Trans. Chicago Path. Soc., *10,* 92.

The antigenic properties of β-nucleoproteins. J. Biol. Chem., *28,* 11.

1917

(With M. Slye and H. F. Holmes) Primary spontaneous sarcoma in mice. J. Cancer Res., *2,* 1.

(With M. Slye and H. F. Holmes) Comparative pathology of cancer of the stomach with particular reference to the primary spontaneous malignant tumors of the alimentary canal in mice. J. Cancer Res., *2,* 401.

(With M. Slye and H. F. Holmes) The comparative pathology of cancer of the stomach. Trans. Chicago Path. Soc., *10,* 209.

(With A. H. Arlitt) The effects of alcohol on the reproductive tissues. Trans. Chicago Path. Soc., *10,* 261.

(With A. H. Arlitt) The effect of alcohol on the reproductive tissues. J. Exp. Med., *26,* 769.

(With M. Slye and H. F. Holmes) Spontaneous malignant tumors of the alimentary canal in mice. J. Cancer Res., *2,* 494.

Thyroid gland (section on). Reference Handbook of the Medical Sciences, 3rd ed., *8,* pp. 184-195. Edited by Thomas L. Stedman. William Wood & Company, New York, N. Y.

(With C. Jacobson) A primary malignant neoplasm of the Fallopian tube, probably deciduomatous. Surg. Gynec. Obst., *25,* 675.

1918

(With R. G. Perkins) Observations on medical conditions in Roumania. J. Am. Med. Assn., *70,* 743.

The purine metabolism of the Dalmatian coach hound. J. Biol. Chem., *35,* 221.

Chemical Pathology. W. B. Saunders Co., Philadelphia, Pa., 3rd ed., 707 pp.

Symposium on carcinoma II. Carcinoma from the standpoint of the pathologist. International Clinics., *4*, 289.

(With M. Slye and H. F. Holmes) Comparative pathology of testicle tumors. Trans. Chicago Path. Soc., *10*, 291.

1919

(With M. Slye and H. F. Holmes) Primary spontaneous tumors of the testicle and seminal vesicle in mice and other animals. J. Cancer Res., *4*, 207.

1920

(With E. F. Hirsch) Retroperitoneal liposarcoma. Trans. Chicago Path. Soc., *11*, 74.

(With E. F. Hirsch) Retroperitoneal liposarcoma; report of an unusually large specimen, with chemical analysis. Am. J. Med. Sci., *159*, 356.

(With M. Slye and H. F. Holmes) Primary spontaneous tumors of the ovary in mice. Trans. Chicago Path. Soc., *11*, 75.

(With M. Slye and H. F. Holmes) Primary spontaneous tumors of the ovary in mice. J. Cancer Res., *5*, 205.

(With L. DeWitt and B. Suyenaga) The influence of creosote, guaiacol and related substances on the tubercle bacillus and on experimental tuberculosis. J. Infect. Dis., *27*, 115.

(With J. H. Lewis, W. D. Sansum, W. B. McClure and H. P. Lussky) Observations on the toxicity of tetranitromethylaniline (Tetryl), tetranitroxylene (T.N.X), tetranitraniline (T.N.A.), dinitrodichlorbenzene (Parazol), and metanitraniline. J. Indust. Hyg., *2*, 247.

1921

Chemical Pathology. W. B. Saunders Co., Philadelphia, Pa., 4th ed. 695 pp.

The present status of the problems of anaphylaxis. Physiol. Rev., *1*, 44.

The relation of multiple vascular tumors of bone to myeloma. Trans. Chicago Path. Soc., *11*, 151.

The relation of multiple vascular tumors of bone to myeloma. Arch. Surg. *2*, 435.

(With T. B. Osborne) Anaphylaxis reactions with purified proteins from milk. J. Infect. Dis., *29*, 200.

The relation of chemical composition to immunologic specificity. Trans. Chicago Path. Soc., *11*, 203

The occurrence of squamous cell carcinoma in mice. Trans. Chicago Path. Soc., *11*, 205.

(With M. Slye and H. F. Holmes) Primary spontaneous squamous cell carcinomas in mice. J. Cancer Res., *6*, 57.

(With M. E. Maver) The composition of appendiceal concretions. Arch. Surg., *3,* 439.

Aneurism of vertebral artery. Trans. Chicago Path. Soc., *11,* 232.

1922

The absorption of calcium and its deposition in the tissues of experimental tuberculosis. Trans. Nat. Tuberc. Assn., *18,* 485.

Persistent patency of the ductus arteriosus botalli. Trans. Chicago Path. Soc., *11,* 290.

Intracranial aneurysm of the vertebral artery. Arch. Neurol. Psychiat., *7,* 311.

(With J. H. Lewis) The function of the colostrum. Trans. Chicago Path. Soc., *11,* 258.

(With J. H. Lewis) The function of the colostrum. J. Am. Med. Assn., *78,* 863.

Bone metastasis from primary carcinoma of the urinary bladder. J. Urol., *7,* 383.

Primary squamous-cell carcinoma of the kidney as a sequel of renal calculi. Arch. Surg., *5,* 356.

Post-traumatic calcification of the pancreas with diabetes. Trans. Chicago Path. Soc., *11,* 255.

Post-traumatic calcification of the pancreas with diabetes. Am. J. Med. Sci., *164,* 479.

(With M. Slye and H. F. Holmes) Primary spontaneous tumors in the kidney and adrenal of mice. J. Cancer Res., *6,* 305.

(With M. E. Maver) The chemical composition of calcified tuberculous lesions. Am. Rev. Tuberc., *6,* 649.

1923

Relation of clinical to necropsy diagnosis in cancer and value of existing cancer statistics. J. Am. Med. Assn., *80,* 737.

(With M. E. Maver) The alimentary absorption of calcium and its deposition in the tissues in experimental tuberculosis. Am. Rev. Tuberc., *7,* 1.

(With L. DeWitt and E. R. Long) The Chemistry of Tuberculosis. Williams and Wilkins, Baltimore, Md., 447 pp.

Cancer. Prac. Med. Surg., *39,* 231.

The influence of heredity on the occurrence of cancer. J. Am. Med. Assn., *81,* 1017, 1103.

Trimble lecture on the relation of heredity to the occurrence of cancer. Trans. Med. Chirur. Fac. Md., *75,* 17.

(With M. E. Maver) The influence of silica compounds on experimental tuberculosis. Am. Rev. Tuberc., *8,* 318.

(With M. Slye and H. F. Holmes) Primary spontaneous tumors in the kidney and adrenal in mice. Trans. Chicago Path. Soc., *11,* 337.

An analysis of 545 cases of malignant neoplasm observed at postmortem examination. Trans. Chicago Path. Soc., *11*, 371.

(With M. Slye and H. F. Holmes) Primary spontaneous tumors of the uterus in mice with a review of the comparative pathology of uterine neoplasms. Trans. Chicago Path. Soc., *11*, 407.

1924

(With M. Slye and H. F. Holmes) Primary spontaneous tumors of the uterus in mice. J. Cancer Res., *8*, 96.

Human cancer in relation to heredity. Radiology, *3*, 60.

The Chemical Aspects of Immunity. The Chemical Catalog Co., New York, N. Y., 254 pp.

A case of leiomyoma of the stomach with fatal termination. Trans. Chicago Path. Soc., *12*, 5.

The chemical basis of immunological specificity. J. Immunol., *9*, 291.

(With J. H. Lewis, W. F. Hoffman and R. A. Gortner) An immunological and chemical study of the alcoholic-soluble proteins of cereals. Proc. Soc. Exp. Biol. Med., *22*, 185.

1925

Chemical Pathology. W. B. Saunders Co., Philadelphia, Pa., 5th ed., 790 pp.

(With J. H. Lewis) The immunological properties of alcohol-soluble vegetable proteins. J. Biol. Chem., *66*, 37.

1926

(With L. M. DeWitt) An attempt to establish tissue-specific strains of tubercle bacilli. Am. Rev. Tuberc., *13*, 92.

(With M. Slye and H. F. Holmes) The comparative pathology of cancer of the thyroid with report of primary spontaneous tumors of the thyroid in mice and in a rat. J. Cancer Res., *10*, 175.

Some observations on the relation of chemical constitution to biologic specificity. Trans. Chicago Path. Soc., *12*, 186.

(With M. Slye and H. F. Holmes) The comparative pathology of thyroid tumors. Trans. Chicago Path. Soc., *12*, 220.

1927

Cancer statistics as they appear to a pathologist. J. Am. Med. Assn., *88*, 399, 476.

(With J. H. Lewis) The immunologic behavior of mucoids. J. Infect. Dis., *40*, 316.

(With J. H. Lewis and D. B. Jones) Immunologic reactions of the globulins from the seeds of leguminous plants. J. Infect. Dis., *40*, 326.

Immunology as a branch of chemistry. Lecture delivered at Columbia University on the occasion of the opening of the Chandler Chemical Laboratories. Columbia University Press, N. Y.

Waxy degeneration of the diaphragm; a factor in causing death in pneumonia and in other conditions. Arch. Path. Lab. Med., *4,* 681.

Ist der Krebs eine Kulturkrankheit? Med. Welt. *1,* 1284.

1928

Antigens and their specificity. Chapter 50, pp. 702-710. The Newer Knowledge of Bacteriology and Immunology, E. O. Jordan and I. S. Falk. University of Chicago Press, Chicago, Illinois.

Immunity:—the chemical warfare of existence. Pp. 559-601. The Chemistry of Medicine. Edited by Julius Stieglitz. The Chemical Foundation, Inc., New York, N. Y.

Waxy degeneration of the diaphragm as a factor causing death in pneumonia and other conditions. Trans. Chicago Path. Soc., *13,* 11.

1929

(With F. B. Seibert) The effect of aluminum on mammalian blood and tissues. Arch. Path., *8,* 230.

(With R. Mason) On the occurrence of true mixed carcinomatous and sarcomatous tumors (sarco-carcinoma) with report of a mixed carcino—chondrosarcoma of the thyroid of a dog. Trans. Chicago Path. Soc., *13,* 145.

(With R. Mason) On the occurrence of true mixed carcinomatous and sarcomatous tumors (sarco-carcinoma) with report of a mixed carcino-chondrosarcoma of the thyroid of a dog. J. Cancer Res., *13,* 207.

(With S. T. Darling) Beriberi, nutritional edema and epidemic dropsy. Chapter VI, pp. 47-58, in Diseases Due to Dietary Deficiencies, Blumer-Billings-Forcheimer, The Therapeutics of Internal Diseases, *4.* D. Appleton and Company, New York, N. Y.

The Chemical Aspects of Immunity. The Chemical Catalog Co., Inc., New York, N. Y., 2nd ed. 286 pp.

1930

(With P. R. Cannon) Primary carcinoma of the lung following trauma. Trans. Chicago Path. Soc., *13,* 187.

(With P. R. Cannon) Primary carcinoma of the lung following trauma. Arch. Path., *9,* 869.

The evidence furnished by biochemistry and immunology on biologic evolution. Arch. Path., *9,* 1044.

Addison's disease with selective destruction of the suprarenal cortex ("Suprarenal cortex atrophy"). Trans. Chicago Path. Soc., *13,* 326.

Addison's disease with selective destruction of the suprarenal cortex. Arch. Path., *10,* 499.

The influence of heredity on cancer in man. DeLamar Lectures, 1929-1930, 1-19. Williams & Wilkins Co., Baltimore, Md.

The dangers of carbon monoxide poisoning and measures to lessen these dangers. Report 1 of the Committee on Poisonous Gases of the A.M.A., J. Am. Med. Assn., *94,* 179.

1931

The influence of heredity on the occurrence of cancer in animals. Ann. Int. Med., *4,* 676.

(With M. Slye and H. F. Holmes) Intracranial neoplasms in lower animals. Trans. Chicago Path. Soc., *13,* 319.

(With M. Slye and H. F. Holmes) Intracranial neoplasms in lower animals. Am. J. Cancer, *15,* 1387.

The nature and etiology of cancer. Am. J. Cancer, *15,* 1919.

1932

The chemotherapy of tuberculosis. Yale J. Biol. Med., *4,* 611.

(With E. R. Long) The Chemistry of Tuberculosis. Williams & Wilkins Co., Baltimore, Md., 2nd ed., 481 pp.

1933

The chemistry of arteriosclerosis. Chapter 11, pp. 323-353, Arteriosclerosis, E. V. Cowdry. The Macmillan Co., New York, N. Y.

1934

A case of dwarfism associated with lingual goiter and cystic hypophysis. Trans. Chicago Path. Soc., *14,* 190.

(With J. D. Stewart and E. Birchwood) Effect of atherosclerotic plaques on the diameter of the lumen of coronary arteries. Trans. Chicago Path. Soc., *14,* 209.

(With M. Slye) Tumors of islet tissue with hyperinsulinism in a dog. Trans. Chicago Path. Soc., *14,* 212.

1935

(With M. Slye and H. F. Holmes) The comparative pathology of carcinoma of the pancreas, with report of two cases in mice. Am. J. Cancer, *23,* 81.

(With J. D. Stewart and E. Birchwood) The effect of atherosclerotic plaques on the diameter of the lumen of coronary arteries. J. Am. Med. Assn., *104,* 730.

(With M. Slye) Tumors of islet tissue with hyperinsulinism in a dog. Arch. Path., *19,* 537.

Dwarfism associated with lingual goiter and cystic hypophysis. Arch. Path., *20,* 64.

1937

Acute endocarditis produced by bacillus paratyphosus B. Arch. Path., *23,* 270.

(With E. M. Humphreys and E. G. Work) Significance of the increased frequency of selective cortical necrosis of the adrenal as a cause of Addison's disease. J. Am. Med. Assn., *109*, 490.

1938

Report of seven cases of cystitis emphysematosa. J. Urol., *39*, 391.

(With M. Slye and H. F. Holmes) Comparative pathology of cancer of the alimentary canal, with report of cases in mice. Am. J. Cancer, *33*, 223.

Giant cells in cystitis. Arch. Path., *26*, 32.

1940

Adipose tissue, a neglected subject. J. Am. Med. Assn., *114*, 2177, 2284.

Occurrence and significance of congenital malignant neoplasms. Arch. Path., *30*, 535.

1941

(With M. Slye and H. F. Holmes) The occurrence and pathology of spontaneous carcinoma of the lung in mice. Cancer Res., *1*, 259.

1942

(With S. W. Holley) Metastatic calcification in osteitis deformans (Paget's Disease of Bone). Arch. Path., *34*, 435.

1943

(With C. E. Dunlap) Disseminated ossification of the lungs. Arch. Path., *35*, 420.

Seminoma developing in an undeveloped genital anlage. Arch. Path., *35*, 590.

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